DEPARTMENTS OF VETERANS AFFAIRS AND HOUSING AND URBAN DEVELOPMENT, AND INDEPENDENT AGENCIES APPROPRIATIONS FOR 1994

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Departments of Veterans Affairs and...

HEARINGS

BEFORE A

SUBCOMMITTEE OF THE

COMMITTEE ON APPROPRIATIONS

HOUSE OF REPRESENTATIVES

ONE HUNDRED THIRD CONGRESS

FIRST SESSION

SUBCOMMITTEE ON VA, HUD, AND INDEPENDENT AGENCIES

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PART 7

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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DEPARTMENTS OF VETERANS AFFAIRS AND HOUSING AND URBAN DEVELOPMENT, AND INDEPENDENT AGENCIES APPROPRIATIONS FOR 1994

WEDNESDAY, APRIL 28, 1993.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

WITNESSES

DANIEL S. GOLDIN, ADMINISTRATOR

GARY ALLISON, ACTING COMPTROLLER

GREGORY M. RECK, ACTING ASSOCIATE ADMINISTRATOR FOR ADVANCED CONCEPTS AND TECHNOLOGY

ARNOLD D. ALDRICH, ASSOCIATE ADMINISTRATOR FOR SPACE SYSTEMS DEVELOPMENT

RICHARD H. KOHRS, DIRECTOR, SPACE STATION FREEDOM, OFFICE OF SPACE SYSTEMS DEVELOPMENT

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BILLIE J. McGARVEY, DIRECTOR, FACILITIES ENGINEERING DIVISION, OFFICE OF MANAGEMENT SYSTEMS AND FACILITIES

RALPH C. THOMAS, ASSOCIATE ADMINISTRATOR FOR SMALL AND DISADVANTAGED BUSINESS UTILIZATION

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FREDERICK D. GREGORY, ASSOCIATE ADMINISTRATOR FOR SAFETY AND MISSION QUALITY

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SHELBY G. TILFORD, ACTING ASSOCIATE ADMINISTRATOR FOR MISSION TO PLANET EARTH
GARY TESCH, DEPUTY GENERAL COUNSEL
THOMAS UTSMAN, DIRECTOR, SPACE SHUTTLE PROGRAM, OFFICE OF SPACE FLIGHT
ALPHONSE DIAZ, DEPUTY ASSOCIATE ADMINISTRATOR FOR SPACE SCIENCE
ARNAULD NICOGOSSIAN, DEPUTY ASSOCIATE ADMINISTRATOR FOR LIFE AND MICROGRAVITY SCIENCES AND APPLICATIONS

Chairman's Opening Remarks

Mr. Stokes. The committee will come to order.

We are pleased this morning to have before the subcommittee, Mr. Daniel S. Goldin, Administrator for the National Aeronautics and Space Administration, along with his associates.

NASA is requesting a total of $15.264 billion in fiscal year 1994. That compares with an appropriation of $14.330 billion in 1993, an increase of $935 million.

As we hold these hearings, decisions are being made that will affect what we can and cannot appropriate in fiscal year 1994. And, of course, I am talking about the allocation process which is just now getting underway.

We face some very special problems this year. The President's budget request, including the so-called investment package, exceeds the discretionary caps by approximately $5 billion in outlays. That fact, taken together with substantial increases requested for the Labor-Health and Human Services and Education Appropriation Bill in the amount of the $8.9 billion, could, and I want to emphasize the word "could" make this another very tough budget year.

We, of course, will do the best that we can. But, as you know, our ability to provide an increase for NASA above 1993 is totally dependent on the allocation our subcommittee is given.

At this time, I want to recognize the Administrator for his opening statement. And we want to provide you an opportunity also, Mr. Administrator, to present any of your associates who are with you.

Again, it is a pleasure to welcome you back again before this subcommittee.

INTRODUCTORY OF NASA STAFF

Mr. Goldin. Thank you, Mr. Chairman.

I have some prepared testimony. Before I present it, I want to say we in NASA want to work with the Committee. We are very sensitive to the Nation's budget problems. We have attempted to present a five-year plan that is responsive to the attempts to cut the deficit.

Mr. Stokes. We will place your entire written statement in the record in its entirety.

Mr. Goldin. Thank you. At this time I would like to introduce the NASA team.

Mr. Stokes. Feel free to do so.

Mr. Goldin. Gary Allison is the Acting NASA Comptroller; Gregory M. Reck, Acting Associate Administrator for Advanced Concepts; Arnold D. Aldrich, Associate Administrator for Space Sys-

tems Development; Richard H. Kohrs, Director, Space Station Freedom, Office of Space Systems Development; Yvonne B. Freeman, Associate Administrator for Equal Opportunity Programs; Spence M. Armstrong, Associate Administrator for Human Resources and Education; Edward A. Frankle, General Counsel; Deidre Lee, Associate Administrator for Procurement; John D. Schumacher, Deputy Associate Administrator for Policy Coordination and International Relations; Benita A. Cooper, Associate Administrator for Management Systems and Facilities; Billie J. McGarvey, Director, Facilities Engineering Division, Office of Management Systems and Facilities; Ralph C. Thomas, Associate Administrator for Small and Disadvantaged Business Utilization; Jeff Lawrence, Associate Administrator for Legislative Affairs; Jeremiah W. Pearson III, Associate Administrator for Space Flight; Charles T. Force, Associate Administrator for Space Communications; Frederick D. Gregory, Associate Administrator for Safety and Mission Quality; Wesley L. Harris, Associate Administrator for Aeronautics; Wesley T. Huntress Jr., Associate Administrator for Space Science; Harry C. Holloway, Associate Administrator for Life and Microgravity Sciences and Applications; Bill D. Colvin, Inspector General; and Shelby G. Tilford, Acting Associate Administrator for Mission to Planet Earth.

Mr. STOKES. Thank you.

We are pleased to have all your associates with us.

ADMINISTRATOR GOLDIN'S OPENING REMARKS

Mr. GOLDIN. This is the NASA team. I felt you would want to know. They are here to answer questions.

Mr. Chairman, I am pleased to be here today. Over the next five years, $15 billion will be reduced from NASA's proposed runout as of last year. This is equal to one year's funding. Rather, we are going to do things faster, cheaper and better. We are going to reinvent the way this Agency works.

Mr. LEWIS. That is a good line.

Mr. GOLDIN. We are engineers and scientists and we try and invent, sir, and I want to be responsive. As you know, we are presently reworking the Space Station plan to accommodate the proposed cuts in funding. I want you to know that the President stands behind the redesign process. I am convinced the Space Station produced by this exercise will give us the human research facility this Nation needs, yet will not bankrupt the many other NASA programs.

The United States leads the world in space-based science. This budget continues those critical programs—AXAF, Cassini, Mission to Planet Earth, to name a few—and we intend to be sure those costs don't run out of control. If that happens, we will consider terminations under the program reforms we presented to you last month.

We have reduced planned shuttle costs over a five-year period, of $3.5 billion. We have added $3.9 billion in upgrades to assure safe operation of the system. Safety is the number one priority in the NASA program.

As you know, it seems the Agency takes a hit in the media every time we have to have a launch scrub. To me, a launch scrub is proof that the system works. It is visible evidence that the safeguards work that we have built into the system, and that the instincts of the shuttle managers and the policy on safety for all work.

What we have presented for this initiative takes us in new and bold directions. Consider, we propose to involve nontraditional contractors, in fact, non-aerospace companies, in the development of new NASA technologies.

We plan to look at nontraditional university partners like historic black universities and traditional colleges for university-based research. We will be working with other Federal agencies in the initiatives for major new technologies, like the clean car and a hand-held laser element for the blind. We will judge the success or failure of these contracts by specific indices such as the quantity of technology transfer generated and the amount of industry dollars invested in other elements.

We propose that the great majority of these funds go to support industry and the technology it generates, not NASA centers. We expect that the technology generated by these funds will become available in the short-term, in some cases, within a year, and we recognize that we must deliver in the short-term. We cannot continue to stretch out our programs year after year. We cannot postpone accomplishments or return on investments from one year to the next.

We propose to reinvigorate first the first "A" in NASA, aeronautics. Over the last 25 years the U.S. market share in civil transports has dropped from 99 percent to 67 percent. Nearly one million men and women depend on the aeronautics industry and neither the President nor I intend to stand by and watch these jobs go by.

We have implemented two major procurement reforms based on your guidance. We shall be implementing them earlier, as you had suggested. I thank you for your leadership in this matter.

In summary, Mr. Chairman, and Members of the Subcommittee, I bring to you a NASA budget that is substantially different than in past years. We remain leaders in space and we shall lead the world. We recognize the world of the 1990s is different. We must live within a constrained budget and we must reach out to a culturally diverse work force in ways that assure many nontraditional contractors have an opportunity to participate.

We must be able to show you, the Congress, and the American people, the results of those investments, not a decade from now but just a year from now. I pledge to you that these will be my goals and NASA's goals.

I will be pleased to answer any questions that you may have.

[The information follows:]

Statement of

Daniel S. Goldin
Administrator
National Aeronautics and Space Administration

before the

Subcommittee on VA-HUD-Independent Agencies
Committee on Appropriations
House of Representatives

I am pleased to be here today to describe NASA's FY 1994 budget request for the Subcommittee. As you know, the President has submitted to the Congress a request totalling $15.265 billion for NASA. A detailed summary of this request is appended to my statement as Attachment I. This budget proposal represents a great deal of hard work by many dedicated people, and, I believe, marks a profound change in the way we propose to do business at NASA.

Fundamentally, this budget reflects NASA's acceptance of the President's challenge to produce a realistic five-year funding plan for NASA, while also making our programs more relevant to America. NASA's budget is responsive to the President's new technology initiative, "Technology for America's Economic Growth -- A New Direction to Build Economic Strength." This initiative recognizes that investments in technology offer new opportunities for creating higher-wage, higher-skills jobs for more competitive businesses. The initiative also recognizes that the best way for the Federal Government to ensure its investments are commercially relevant is through cost-shared and jointly-planned technology development partnerships with industry and academia. Consistent with his initiative, the President's budget accommodates a robust plan for ongoing NASA programs, a redesigned Space Station, and a series of potential new technology activities.

I would like to begin by outlining the larger five-year budget picture which is represented in the President's request for NASA, and is displayed in Attachment II. The five-year spending plan assumed by NASA in the President's FY 1993 budget submission, projected one year, reflected a total projected NASA expenditure of $96.1 billion for FY 1994-1998. Under President Clinton's FY 1994 budget plan, NASA has eliminated a total of $23.8 billion from programs in our previous five-year spending plan. I am proud to say that nearly one-half of these reductions were identified last year by NASA's Red and Blue internal review teams in the form of program restructurings, management efficiencies, and changes in contract structure or

new ways of doing business. After making a total reduction of $23.8 billion to NASA's previous plan, $8.1 billion was added in terms of new programs and new technology initiatives designed to bring increased return for America. The bottom line is that, when comparing the five-year runout of NASA's plan last year with the President's FY 1994 budget, there is a net reduction in planned NASA spending over the next five years of approximately $15 billion. At our current funding level, that is equivalent to deleting an entire year's worth of funding out of our five-year plan.

While the President's budget reflects major reductions in planned NASA spending over the five-year period, it represents an increase of $935 million above the FY 1993 appropriations level. This funding level is designed to provide adequate resources in FY 1994 for increases in ongoing programs, and to cover transition costs for whatever option the President identifies for Space Station, while allowing us to initiate a mix of exciting new technology programs. Beyond FY 1994, NASA's budget reflects incremental annual growth for inflation.

Space Station Redesign/Technology Investments

Fundamental to the success of the President's FY 1994 budget plan for NASA is the redesign of the Space Station. The previously planned Space Station Freedom program is unaffordable in light of total constraints on NASA's budget, funding needs of other NASA programs, recent Station cost growth, and the President's direction that NASA invest in new technology projects that can contribute sooner and more directly to the U.S. economy and technological/scientific goals. The President has directed NASA to redesign the Space Station so as to substantially reduce development, operations and utilization costs while maintaining early capability to conduct high priority scientific and technological research. The redesign of the Station will enable a rebalancing of priorities across the Agency, to permit increased investment in a variety of science, space and aeronautical research and technologies which will be accomplished more rapidly and made available to a broad spectrum of U.S. industry.

NASA's role in the redesign effort is to be "an honest broker," to set up a process to develop a range of possible options and work with a Blue Ribbon Panel of experts which will assess and establish the advantages and disadvantages of each option as an input to the Administration where a final decision will be made. Our charter for the Station redesign effort stipulates that we:

- develop options which result in a program that is more efficient and effective and capable of producing greater returns on investment;

- significantly reduce development, operations and utilization costs while achieving many of the current goals for long-duration scientific research;

- consider all phases of the program design, assembly, operations, utilization and management of the Space Station;

- for all program options, utilize, as much as feasible, the efforts to date of the Space Station Freedom program;

- address options for achieving earlier research results prior to Space Station availability; and,

- develop redesign options which continue to accommodate and encourage international participation.

Mr. Chairman, we are resolved that the redesigned Space Station be a useful, vital laboratory for the conduct of meaningful research. Toward this end, we have worked closely with the user community, our international partners, and such independent advisors as the National Academy of Sciences, the National Research Council, Space Science and Applications Advisory Committee and its Space Station Science and Applications Advisory Subcommittee, the Aerospace Medicine Advisory Committee, the Task Group on Utilization and Operations, the Space Systems and Technology Advisory Committee, and the Centers for the Commercial Development of Space. Together, we are working to identify the high-priority microgravity objectives of the materials and life sciences disciplines, and the design requirements necessary to meet their requirements. Accordingly, the Space Station redesign will provide power, volume, microgravity environment, data and communications consistent with user requirements.

Three cost options for the Station redesign have been identified for the five-year period from FY 1994 through FY 1998: $5 billion, $7 billion, and $9 billion. These funding levels would include development, utilization, shuttle integration, facilities, research operations support, transition costs, and augmented early flight research. NASA's Station Redesign Team is scheduled to report on a range of detailed options to the President's Advisory Committee on the Redesign of the Space Station on June 7. The Advisory Committee plans to make recommendations on each of the options to the White House on June 10.

Most importantly, the redesign of the Space Station will allow implementation of a far-reaching New Technology Investment package which could reinvigorate our industrial base and enhance America's competitiveness in the global marketplace. The combined Space Station/Technology Investment

wedge is identified in the President's budget at a constant $2.3 billion level throughout the funding period. The elements of the Technology Investment package will emphasize focused, innovative approaches to push technology development, tied to the Administration's funding determination for the redesigned Space Station. A budget amendment outlining spending levels and program plans for the redesigned Space Station and the spectrum of technology initiatives is planned to be submitted to the Congress in June, following completion of the Space Station redesign activities.

Reductions Reflected in FY 1994 Request

Let me now describe for the Committee the specific reductions reflected in the President's budget. These items are outlined in Attachment III.

While the Administration has not yet made a decision on a specific funding level for Station, we are evaluating technical options which would be accommodated under three alternative funding scenarios as mentioned. Cost options being considered for the redesigned Station represent reductions of $6-10 billion over five years.

We have reduced planned Shuttle costs by $3.4 billion over the five-year period, through improved efficiency of operations, definition of work no longer required which could be eliminated, and prioritization of all work not mandatory to safely accomplish the Shuttle flight manifest. We remain fully committed to Shuttle safety and technology upgrades.

We are also targeting infrastructure costs for reduction. Under space communications, we have cancelled TDRS-II, and will instead procure spacecraft functionally equivalent to the existing design as an interim solution to NASA's pressing tracking needs. This will give NASA time to carefully review future requirements and develop, with industry, a new generation of spacecraft using innovative technologies which will lower costs and further the capabilities of the space communications industry. At the same time, our goal will be to reduce planned Construction of Facilities funds by $.6 billion, and our NASA workforce costs by $.7 billion, with the latter to be achieved through means other than involuntary reductions-in-force.

We have identified significant additional savings through restructuring of the Cassini probe to Saturn, the Advanced X-Ray Astrophysics Facility (AXAF), and the Earth Observing System (EOS). Cassini has been rescoped to meet a smaller level of funding this year, and smaller total runout cost, while preserving its major science objectives and the October 1997 launch date. The AXAF mission now includes two spacecraft, the result of a redesign that saved $300 million.

The first spacecraft, AXAF-I, will be launched on either the Space Shuttle or a Titan IV in FY 1998. The second spacecraft, AXAF-S, will be launched on a medium-class expendable launch vehicle in calendar year 1999. This change plays to certain design strengths and will end up saving the taxpayers money while preserving the essential science goals of AXAF. The EOS redesign has saved $2 billion over the five-year period. This reduction was accomplished without delaying the June 1998 initial EOS-AM-1 launch readiness date, and by maintaining the essence of planned instrument complements and science.

This budget also terminates effort on the National Launch System while we pause to explore all possibilities for new space transportation technologies which will enable the United States to lead the industry, not just reach parity several years behind our international partners. We also have terminated the Space Exploration Initiative in recognition of the near-term limits to our resources and other priorities. However, we have not abandoned our intent to go back to the Moon and to push on to Mars; in fact, this budget preserves options to develop small lunar orbiters which could carry out the first post-Apollo scientific discovery flights to the Moon.

Finally, we have identified other efficiencies and reductions over the five-year period for a total of $3.5 billion saved from the previous plan. These include cancellation of the space nuclear power program and Government-wide reductions in administrative costs.

New Content Addbacks in the FY 1994 Budget

Let me now turn to the items we added to the budget following the reductions. These are displayed in Attachment IV.

While we have made major reductions in planned Shuttle costs through efficiencies achieved over the planning period, we remain committed to Shuttle safety and technology upgrades. The budget reflects continued investment in a more reliable Space Shuttle Main Engine as well as avionics upgrades. It also includes investment in the technology for a 30-day Long Duration Orbiter and finances missions to Russia's MIR space station including an astronaut visit in 1994 and a shuttle mission in 1995.

Secondly, we have included initial funds for Gravity Probe-B, an extremely technically challenging fundamental physics experiment to verify Einstein's theories of relativity.

The major third category is new technology investments, including augmentations to our aeronautical program. NASA's aeronautics program is critical to the future of an American industry that involves one million jobs. This is an important phase in a significant upgrade of NASA's aeronautical

capability. Our budget request will support four major areas of improvement in the aeronautics program:

- o high-speed research leading to industry development of an environmentally acceptable and economically sound American supersonic transport;
- o new technologies for subsonic long-haul aircraft, general aviation and commuter aircraft, and investments in the new and expanding field of remotely piloted vehicles;
- o major upgrades to our national aeronautical facilities; and,
- o continued investments in a restructured joint NASA/DOD hypersonic research program to develop and demonstrate technology required to permit the Nation to develop reusable, single-stage-to-orbit vehicles with airbreathing primary propulsion as well as horizontal takeoff and landing.

This budget marks the largest increase in aeronautics funding in decades. Overall, NASA's aeronautics R&D program is increased by 17.9 percent in FY 1994; by FY 1998, the cumulative increase will be more than 55 percent. If additional funding is identified for even more aggressive wind tunnel revitalization, that level of growth may be even greater.

This request accommodates continued funding for the Advanced Solid Rocket Motor, which was restored by the Congress in FY 1993. Consistent with overall NASA funding constraints, the ASRM schedule has been further adjusted to match funding availability in FY 1994 and future years. The ASRM will improve system safety and reliability of the Shuttle while increasing payload lift capability.

The elements within the President's Technology Investment package will emphasize focused, innovative approaches to push the horizons of American technology. A listing of potential investments in this proposal are displayed in Attachment V. Some examples of new projects that could be proposed include:

- o Technology Research Institutes -- These institutes would be consortia combining the talents of NASA, the aerospace industry and universities. Through the institutes, industry and academia would gain access to the NASA centers, with the goal of developing dual-use technologies, and finding ways to push the early application and commercial use of new products and techniques. Graduate students would study at the institutes, and undergraduates would work alongside aerospace professionals.

- Automation and Robotics -- Two key areas in the technology of tomorrow are automation and advanced robotics. Many of the most promising technologies of the future will come from our work to improve our automated and robotic capabilities for Earth observation satellites, deep space probes and astronomical observatories. Automated rendezvous and docking programs could reduce the cost for resupply of the Space Station. Efforts being considered include cooperative demonstration flights with the Russian and European space programs.

- Small Spacecraft Technology and Applications - this initiative would focus on pushing ultra-light, low-cost satellite and instrument technology through both novel data purchase and more traditional flight demonstrations. Small spacecraft technology has evolved significantly over the past several years. It appears that science missions using these technologies may now be developed and launched in less than two years and at significantly reduced cost. These technologies could be pushed through user-defined and competitively-selected data purchase partnerships involving the government, researchers, and industry. The government would pay for only its technology contributions if the data was not delivered. Several missions could be done each year providing useful science data and extensive training opportunities for the next generation of scientists and engineers. In addition, some portion of the funding would be used to further push this technology through joint NASA-industry technology flight demonstrations.

- Aeronautics Technology Augmentation -- As previously mentioned, NASA would push aeronautical technology in the areas of high-speed flight research, subsonic, hypersonic testing and revitalization of the national aeronautical facilities.

- New Small Earth Probes and Global Monitoring -- This program could be a direct beneficiary of the small spacecraft technology program. There are many gaps in the data scientists need to accurately assess the extent and impact of global climate change. These small Earth probes could be used to fill those gaps, searching for specific strands of information to fill the larger data base, and complementing the planned system of larger Earth Observing System science platforms. These missions could involve creative cooperative arrangements, including data purchase arrangements with industry and universities.

- New Small Deep Space Probes for Science and Exploration -- This initiative would provide increased opportunities for universities and industry to participate in NASA's planetary exploration program. Under consideration is a new class of small, low-cost "Discovery" missions similar to the "Explorer" class

missions in physics and astronomy. The Discovery probes would feature highly focused science objectives with a small complement of instruments, strict cost caps, short development times and the use of small launch vehicles.

- Science Research and Analysis -- Increased funding in this area would enable improved analysis and distribution of data from ongoing science missions. This program could expand the involvement of women and minorities in NASA's scientific enterprise, while enhancing the scientific capabilities of the nations universities in Earth and space science.

Depending on the balance between the redesigned Space Station and the tech packages, we may be able to start as many as four new series of small spacecraft in FY 1994. For example, we could possibly move ahead with the Discovery program, the advanced Earth probes, tech-sats and lunar probes. The base program provides for starting a variety of other spacecraft during the five-year period.

- Advanced Launch Technology -- The U.S. will continue to pursue lower cost access to space. This initiative could be conducted on a cost-sharing basis with other agencies and with industry to enhance propulsion, develop lower-cost engines, and investigate new approaches such as hybrid rockets and other low cost propulsion systems.

- Expendable Launch Vehicle Improvements -- NASA is considering funding contractor-managed upgrades to expendable launch vehicle technology using novel contracting approaches.

Summary

Taken together, these initiatives and the new funding trends we are announcing today represent a sea change for NASA's programs. We expect to provide opportunities to expand the participation of minority- and women-owned businesses, academic institutions of all sizes, and entrepreneurial enterprises to work with NASA toward concentrating on demanding missions that utilize innovative technology that can, in turn, be applied on Earth to energize our industrial base.

We held a series of town meetings all over the country this past year to seek the wise counsel of the American people. NASA plans to hold another series of meetings which will gather views on implementation of the President's new technology projects from a wide variety of voices across the Nation. We will invite representatives from a broad spectrum of the business and academic communities to share their ideas on how to make new NASA projects more relevant to the American people. The success of forging new partnerships depends on improving

communications. These meetings will provide a continuing dialogue with academia, industry, and technology communities and groups that will receive the greatest benefit from the new initiatives.

We have already begun a process of change within the NASA institution. Nearly one year ago, we initiated an intensive internal Agency review involving "Red and Blue" teams and institutional teams to examine all our programs and the manner in which we conduct our business. These reviews were a unique opportunity to undertake an important, critical self-evaluation. The teams focused on identifying requirements which could be eliminated, efficiencies which could be incorporated, and ways in which NASA's programs could be made better, faster, and cheaper. As I mentioned earlier, their efforts identified savings for NASA in excess of $10 billion over five years. A special team assessed current procedures for planning and initiating programs within the Agency, and have undertaken improvements which will result in reduced cost and technical risk on new and future NASA aeronautics and space flight programs. Institutional teams also identified a number of weaknesses in existing program management and procurement practices which have contributed to past cost growth in NASA programs, and which formed the basis for a series of broad management and procurement reforms upon which NASA has recently embarked, which, I am confident, will put NASA solidly back on track.

We intend to continue to ensure that, as a cutting-edge institution, diversity is at the root of our workforce, and to enhance that workforce by inviting greater participation of minorities, women and the disabled. And we intend to continue to make progress in expanding the percentage of our annual contracted effort which is conducted by small disadvantaged businesses, with great hopes of reaching our projected goal of 8% in FY 1994.

I believe this budget address America's long-term interests in civil space and aeronautics. It is a fair budget, and if we execute it properly, we should have a more balanced program in the future. We will be able to make some of the critical investments this country requires to push its technology forward into the 21st Century. In the process, I believe we will make the overall NASA program a much healthier enterprise.

By early in the next century, we could have a new fleet of small capable spacecraft exploring the solar system, while advanced hypersonic, supersonic and subsonic aircraft in development will be revitalizing America's aeronautical base and our access to space. We could have a new stable of low-cost, ultra-reliable expendable launch vehicles to further augment our ability to get this new array of scientific payloads into space. We could have a productive Space Station opening new frontiers from its vantage point in low-Earth orbit. We could have a much healthier, balanced set of programs that make a difference to America.

For the past 35 years, NASA has been a source of wonder and hope for the future to America and the world. NASA must be successful in addressing the financial and technological challenges facing us today so that we can continue to inspire young and old alike, help rekindle the American spirit, and rejuvenate the economy. If we can make these contributions represented by the President's budget for NASA today, I believe we will help this Nation reap rich benefits from our science and technology investments tomorrow.

Thank you very much, Mr. Chairman, for this opportunity to describe the President's FY 1994 budget proposal for NASA. I would be pleased to respond to any questions you may have.

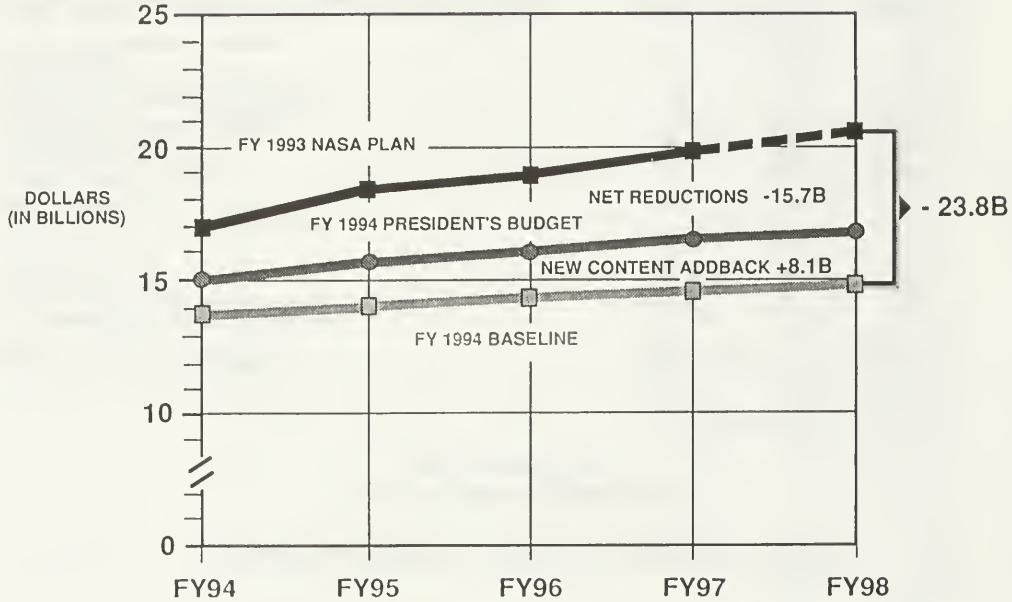
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FY 1994 BUDGET SUMMARY
(Millions of Dollars)

	Budget Plan		
	1992	1993	1994
RESEARCH AND DEVELOPMENT	**6,827.6**	**7,089.3**	**7,712.3**
Space station & new technology investments	2,002.8	2,122.5	2,300.0
Space transportation capability development	739.7	649.2	649.2
Physics and astronomy	1,036.7	1,103.8	1,074.7
Planetary exploration	534.2	473.7	557.2
Life sciences	157.6	140.5	
Life & microgravity sciences & applications			351.0
Space applications	985.1	1,148.0	
Mission to planet Earth			1,074.9
Space research and technology	309.2	272.7	298.2
Commercial programs	147.6	164.4	172.0
Aeronautical research and technology	788.2	865.6	1,020.7
Transatmospheric research and technology	4.1	--	80.0
Safety, reliability and quality assurance	33.6	32.7	35.3
Academic programs	66.8	92.9	74.5
Tracking and data advanced systems	22.0	23.3	24.6
SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS	**5,384.8**	**5,086.0**	**5,316.9**
Shuttle production and operational capability	1,296.4	1,053.0	1,189.6
Shuttle operations	3,029.3	3,016.0	3,006.5
Launch services	155.8	180.8	300.3
Space and ground networks, communications & data systems	903.3	836.2	820.5
CONSTRUCTION OF FACILITIES	**531.4**	**525.0**	**545.3**
RESEARCH AND PROGRAM MANAGEMENT	**1,575.8**	**1,615.0**	**1,675.0**
INSPECTOR GENERAL	**13.9**	**15.1**	**15.5**
TOTAL BUDGET AUTHORITY	**14,333.5**	**14,330.4**	**15,265.0**

NATIONAL AERONAUTICS & SPACE ADMINISTRATION

FY 1994 President's Budget



FY 1994 President's Budget
Five-Year Summary (FY 1994 - FY 1998)

REDUCTIONS

	FY 1993 Budget Runout	FY 1994 Budget Runout	Δ
	(Dollars in Billions)		
Space Station	15.1	7.1*	-8.0
Shuttle	22.8	19.4	-3.4
Infrastructure Reductions	18.5	15.7	-2.8
Space Communications	6.8	5.3	-1.5
Construction of Facilities	2.2	1.6	-0.6
Civil Service Costs	9.5	8.8	-0.7
Restructure	10.7	8.1	-2.6
CASSINI	1.7	1.4	-0.3
AXAF	1.9	1.6	-0.3
EOS	7.1	5.1	-2.0
Terminate NLS	3.0	0	-3.0
Terminate SEI	0.5	0	-0.5
Other Efficiencies & Reductions	25.5	22.0	-3.5
TOTAL	96.1	72.3	-23.8

*The Administration has not made a decision on the funding level for the Space Station. Three budget options are being examined and the exact funding level is dependent on the outcome of the Space Station redesign effort.

FY 1994 President's Budget

NEW CONTENT ADDBACK

- Shuttle Improvements
- Gravity Probe-B
- Aeronautics
- New Technology Investment Candidates*
  (Includes Aeronautics Augmentations)
- Advanced Solid Rocket Motor

* Specific projects have not been identified. Total funding and content are dependent on Administration decisions after the Space Station redesign effort study is completed.

FY 1994 President's Budget

New Technology Investment Candidates

- Space & Aeronautics Technology Development and Flight Programs
  - Technology Research Institutes
  - Automation and Robotics Technology
  - Small Spacecraft Technology and Applications
  - Aeronautics Technology Augmentation
- Scientific Earth Satellites and Deep Space Programs
  - New Small Earth Probes and Global Monitoring
  - New Small Deep Space Probes for Science and Exploration
  - Science Research and Analysis Augmentation
- Launch Vehicle Advancement Programs
  - Advanced Launch Systems
  - Expendable Launch Vehicle Improvements

NEW STARTS

Mr. STOKES. Thank you, Mr. Administrator. We appreciate that presentation.

It will be the intention of the Chair to have this subcommittee go into the area of general questions, and the Chair will also ask a few budget questions, so we will sort of intermix the two.

During the recent legislation of this subcommittee held on cost overruns, you pledged several points to us. At that time, based upon these points that you have pledged to us: One, you pledged that NASA will not bring programs forward to the Congress or the White House for development which have not been fully defined. Two, that NASA will terminate contracts for cause. Three, NASA will implement a revised award fee policy which will require return of fee by contractors whose products and procurement plans do not meet stated objectives. And four, that NASA will not allow requirements to grow so that we build gold-plated systems or allow contractors to get well.

My question is: What are the potential new starts in this budgets; also, tell us whether or not they meet your criteria, as I have just referenced it?

Mr. GOLDIN. In the traditional sense, in the basic portion of the budget we do not have a new start. However, the Tracking and Data Relay Satellite, one where we are going to procure three additional satellites, as I recollect that could fall within the criteria to establish firm requirements before the RFP goes out.

Gravity Probe-B is a continuation of a program, but we shall not commence with the Phase C/D development activities on that spacecraft until we have a review.

In the Technology Package that accompanies the Space Station, there are a number of potential new program starts. Those programs will not be started without this. My recollection is that there is the Discovery series. We would not start the Discovery Program without this peer review. I believe I said if the program is over $200 million, it meets the threshold for program review and we are going to stick with it. I think we gave you a listing of programs in our answers to questions.

Mr. STOKES. Has the program council signed off on the new starts?

Mr. GOLDIN. No. We have just begun the process of establishing the Program Management Council. Even though Earth Observing System (EOS) just was awarded, we, indicated that we felt it was crucial to have the Program Management Council review the Earth Observing System Data information System (EOSDIS) program over the next few months.

Mr. STOKES. Have you as an administrator terminated any contracts for cause?

Mr. GOLDIN. Not yet.

NEW FEE REGULATIONS

Mr. STOKES. Since we held the overrun hearings one major contract, I believe, was let. That is the Earth Observing System, EOSDIS.

Did that contract meet all those criteria and would it be fair to say you are not applying the new fee regulations to that contract because, of course, those regulations have not been finalized.

Mr. GOLDIN. That contract was let before we advertised in the Federal Register. As a result, it was completely negotiated. However, I do want to point out that I have asked Mr. Dailey who is the Acting Deputy Administrator and my Chief of Staff for NASA, to conduct a Council review of that EOSDIS program and come back to me if he establishes that it meets our criteria. If not, we will have to make some changes in that program and we will report those changes to this Committee.

Mr. STOKES. The fee regulations advertised in the Federal Register, when do you anticipate final promulgation of those?

Mr. GOLDIN. I will ask Deidre Lee.

Ms. LEE. We did publish those regulations for comment on April 15. I anticipate it being open for comment for 30 days.

We will take them all and work through and make sure we have no major issues and, hopefully, publish the final rule this summer. All the new activities coming up, RFP releases or solicitation releases, will address that issue as appropriate.

Mr. STOKES. We are talking about late June or July?

Ms. LEE. I would say we are talking about late July or August. We are looking at performance incentives making sure, even as the comments come out, that the issues are addressed.

Mr. STOKES. I get the sense that the new Tracking and Data Relay Satellite Program "buy" would not be covered by the new fee regulation. If that is correct, why not? Given that the RFP has not been released as yet—and should not be until after we have finalized the 1994 budget.

Mr. GOLDIN. We will commit to this Committee that we will examine this procurement to determine if it is appropriate to incorporate these new requirements. We think that is a fair, legitimate request.

Mr. STOKES. If the money is available for the new TDRS "buy," and that is an "if," it would seem that NASA should be able to incorporate the new fee structure in that RFP; is that correct?

Mr. GOLDIN. That is a big enough contract that we should not allow it to slip through without examining it.

SPACE STATION AND NEW TECHNOLOGY INVESTMENTS

Mr. STOKES. Let's turn now to the Space Station Program, Mr. Administrator, which is detailed on page RD1-1-one. As the justifications indicate, NASA is requesting $2,300,000,000 for the space station and what you are describing as "new technology investments"; is it correct? That the size of the new technology will be determined once the space station redesign has been done and transmitted to the committee in the form of a budget amendment?

Mr. GOLDIN. Yes, sir.

Mr. STOKES. Is it also true that the size of the technology package will be determined, at least in part, by what space station option is chosen?

Mr. GOLDIN. Yes, sir.

Mr. STOKES. Is it also correct that the options are $5 billion through fiscal year 1998, $7 billion through fiscal year 1998, and $9 billion for fiscal 1998?

Mr. GOLDIN. Yes, sir.

Mr. STOKES. Mr. Administrator, facing a cost growth somewhere between $500 million and $1 billion, depending on how it is scored, you constituted a special independent cost assessment team that is scheduled to report next week; is that correct?

Mr. GOLDIN. Yes, sir. I will have my first meeting with them next month and I will get the results. I don't know what it will be.

Mr. STOKES. So the results will not come out next week. It will be your first meeting with them.

Mr. GOLDIN. Yes.

Mr. STOKES. Is it also the purpose that that assessment theme is to provide a relatively stable estimate of the costs to completion of the existing space station.

Mr. GOLDIN. Let me word it a little differently. It was the purpose of this independent assessment team, made up of employees from the Comptroller's Office and employees who are not part of the Space Station Program, to give the Administrator an independent assessment of all aspects of the program, to do a risk and contingency analysis so that we have a very good basis to understand the projected costs of the space station.

SPACE STATION STATUS

Mr. STOKES. Let me describe the existing space station status of last December. As I understand it, the 1994 request was targeted at $2,250,000,000—and following the January cost growth, all reserves were subscribed and an unresolved $500 million problem remained; is that essentially correct?

Mr. GOLDIN. At that time, I believe that is what was reported.

SPACE STATION COST ESTIMATE

Mr. STOKES. Now let me ask Mr. Dick Kohrs what today's best cost estimate is of building the existing space station, on an annual basis beginning in 1994, with further scrubbing of hardware and people?

Mr. KOHRS. With the management efficiencies and the operations efficiencies that are being looked at by the redesign team—we have looked at some of these efficiencies before—plus reducing station a bit in terms of the PV modules—we are still debating whether we should have the half module or whether we can use some of our half facilities in some of the other modules—we think it is a little over $2 billion a year for the next five years. It would take you from 1994 through 1998 at roughly $2 billion a year to build what I would call an equivalent Space Station to our baseline. With that, we have earmarked $100 million in reserves in 1994, $250 million in reserves in 1995, and $400 million in reserves in subsequent years; that has been the reserve baseline.

Mr. STOKES. Mr. Kohrs, what hardware would you scrub?

Mr. KOHRS. Primarily, maybe the hab module; maybe one truss section. We put up the same pre-integrated truss sections, and we are looking to go back and maybe reduce one section of truss.

Mr. STOKES. How many contractor people would have to come off the rolls to meet that estimate? I believe you told us a few weeks ago at the other hearings that you were looking at a reduction of 4,000 in order to achieve an annual cost of $2 billion.

Mr. KOHRS. Our 1994 OMB request is $2.25 billion. The 1995 number is $2.44 billion. If you reduce that number to $2 billion you are talking about $400 million at $100,000 per person year; that is about 4,000 people. That number is plus or minus, but that is equivalent to the 4,000 we talked about last time.

Mr. STOKES. What other scrubs have you incorporated into that estimates?

Mr. KOHRS. Primarily, management scrubs, such as the recommended combining of the Level I and Level II organizations. The redesign team is looking at reductions to the operations budget. We have also looked at that over the years. Any of these options that come out of the redesign activities can take advantage of the majority of the ops scrub that the redesign people are looking at.

Mr. STOKES. When we last left the space station, we were talking about a four, six, and nine month delay in the first element launch, man-tended, and permanently manned dates, respectively.

What do these new cost estimates and changes to the existing space station drive in additional delays?

Mr. KOHRS. With this $2 billion a year in the station I described, we would have to slip another twelve months in the first element launch and the man-tended capability launch.

Mr. STOKES. What are the reserves in the slimmed down existing space station in fiscal years 1994 and 1995?

Mr. KOHRS. 1994 would be $100 million and 1995 would be $250 million and 1996 and subsequent years, $400 million per year.

INDEPENDENT COST ASSESSMENT TEAM

Mr. STOKES. Do the numbers you have been talking about cost up with what the independent cost assessment team is looking at?

Mr. KOHRS. We have had a meeting with them. As Mr. Goldin said, he has some independent people from the Comptroller's Office and some other people from around the NASA centers conduct a review. Our job is to be sure we provide them with all the data from our project people and our subsystem people, so they can understand how we budget and agree or disagree with our numbers. So we supply them with data, but the independent cost team is, as they should, making their independent budgets.

REDESIGN TEAM OPTIONS

Mr. STOKES. One of the options being studied by the redesign team is the existing space station. Our staff was briefed on that last week, and as I understand it, the option is being pursued with virtually the same hardware in the existing program minus perhaps the habitat towards and effort of building the existing station for only $9 billion through fiscal year 1998.

Now, Mr. Administrator, one of the things that you have pledged to us is that we will no longer be sold unrealistic assumptions and that programs coming to us will have sufficient reserves.

I also think it is important for us to pledge that we won't appropriate money for programs that do not meet those same parameters. In short, if we don't have enough money, we both need to take programs off the plate rather than continually short funding activities at the expense of overall increased costs—because that only exacerbates the problem.

So I think you can understand how it could strain NASA's credibility if in the next three or four weeks you come to us with an option that in effect suggests NASA can build 95 percent of the existing space station for only $1.6 billion in 1994 and $9 billion in total, when in January we couldn't do the job for $2.3 billion.

Mr. GOLDIN. We will come forward with numbers we believe in. We will come forward with adequate reserves. And if we cannot do the right thing, we will not come forward. There are a variety of techniques we are looking at. We are considering the use of existing or rebuilt military hardware. They are in final acceptance tests right now, so the costs of that hardware should be firm. That is one of the configurations. In another configuration, we are considering the use of shuttle hardware in lieu of hardware that we have. We are trying to take existing off-the-shelf hardware. In addition to the independent cost assessment team, I have asked Jim Weatherbee to take a look at the requirements for the Space Station. There are a whole host of requirements for the Space Station that we believe, if we change, will not detract from the science, but if we change those requirements, we could be able to reduce the hardware requirements.

We are not going to pull a rabbit out of a hat. We are going to do very standard things. The data management system on this Space Station is much too complex. It is unreasonable to ask for 2.3 million lines of code from a data management system that takes kilowatts worth of power. We don't have to gold plate that. The Independent Requirements Assessment Team is suggesting other ways of looking at the data management system. So we are going to take a look at all the different systems, come up with all the numbers and come forward with our best assessment, and we are going to put a reserve on it.

We are going to do our very best to address the $5, $7 and $9 billion options, but if we cannot come forward with something credible, we won't.

I am very proud of the team that is working on this, the people located in Crystal City and their support staff, NASA, Johnson; NASA, Marshall; and NASA, Langley. They are an exciting team. They are looking at bold innovative concepts. We have committed to come forward with new things.

There is one more overlap to this activity. We have invited the Russian Space Agency to come and review our designs and consult with us and to see if there is any existing hardware or designs that they have that would allow us to reduce our costs.

So we are trying to take all these steps. Is it difficult, yes. Is it complicated, yes. I am not prepared to prejudge what is going to come out.

All I can say is we are going to stick to the rules that we have established. We are going to subject ourselves to a very significant peer review. The President's Blue Ribbon Panel is made up of some

of the most preeminent members of the aerospace community. This is not going to be a situation where NASA is going to have a single point design that we will come forward with and say this is it. We will have different options.

It will be peer reviewed and then it is going to go forward to the President for decision. On that peer review team, I might mention, there are two cost analysts who are well-known in the country, and in NASA. They are going to do their own cost assessment. They are supported by a number of other people within the government. So there will be multiple looks at this thing, and I believe there will be adequate data upon which the Committee can judge.

In the end, the Committee will have to judge whether they can accept what we have said. But that is the process we are going through.

MANAGEMENT CONFIGURATIONS

Mr. STOKES. In that context, I hope you understand that we are also concerned about the type of options brought to us with reference to the existing space station and credibility, as it relates to those, also.

Mr. GOLDIN. Yes, sir. In fact, as part of the existing space station, I believe one of the biggest areas of savings will be in the management area. Congressman DeLay inquired about that during last month's hearing. There are five different management configurations we are looking at. We are finding that the lion's share of the cost in the Space Station is not in hardware, but it is in paper and people that support that hardware. So that is a very significant aspect of the existing Space Station design.

Mr. STOKES. I guess from the subcommittee's perspective, one of our major concerns is you being able to go from the 2.3 to the 1.6, and without reserves. We would think you would have to have some reserves in there.

Mr. GOLDIN. We will not come forward with a number that has zero reserves. If we cannot reach a given target level, we will put reserves on top of that. We are not going to do that.

IG'S INITIAL REPORT ON SPACE STATION FREEDOM

Mr. STOKES. Let me ask you one more question before I yield to some other Members. Have you read the IG's initial report on Space Station Freedom and the response of the Space Station Freedom Director? In some ways it is difficult to assess whether the IG is overstating the problem or Space Station management is understating the problem? Have you had a chance to see this report?

Mr. GOLDIN. I have. That report was a preliminary report. I did see it. It was addressed to me. The process we have at NASA is a very open process. The IG does a study, comes up with a preliminary report, and issues that report for comment by a variety of different individuals. I have not seen the response to that report from the Space Station team, but the IG is also requesting inputs for that report from a number of other areas in NASA.

When those inputs are into the IG, and the IG issues a final report, I will be able to make comments on it. But the report that we have now, I view as preliminary. A lot of material gets changed

and corrected in the process, so it is very difficult for me to make a value judgment.

Mr. STOKES. Take work package four of the power package. If you read the IG's comments, you get the distinct impression the recently completed critical design review, CDR, did not meet the normal CDR guidelines. On the other hand, if you read the space station director's response, you come away with the feeling that NASA never meets the 90 percent CDR requirement.

What is your reaction to these two assessments of the same program?

Mr. GOLDIN. I would like to reserve judgment until we have all the facts and take a look at the total picture. I don't feel in a position to comment until I have the data. By the way, we have asked the independent assessment team to take a look at the CDR requirements and criteria.

Mr. STOKES. Thank you.

Mr. Lewis, I yield to you.

REDESIGN SCHEDULE

Mr. LEWIS. Thank you, Mr. Chairman.

Mr. Goldin, welcome.

Mr. Chairman, I do have some general budgetary questions which I may ask later if we have time, but I would like to focus my initial time on the questions you have been asking relative to the station.

Mr. Goldin, are redesign efforts on schedule?

Mr. GOLDIN. Yes, they are. Our objective was by Tuesday night to complete a review of all three designs.

Mr. LEWIS. Tuesday?

Mr. GOLDIN. By next Tuesday, it is our intent to complete review of all three concepts, including the science. Bryan O'Connor conducted such a review in the NASA auditorium with all the participants. I believe at 8:30 last night, he completed that review. That will kick off the first step of the costing analysis to date.

So we are right on target with the schedule that we have established.

Mr. LEWIS. I noted with interest that you mentioned all three. Will all those three designs at $5, $7 and $9 billion meet the conditions required for full participation of our international partners?

Mr. GOLDIN. Let me answer the question a different way.

Mr. LEWIS. Just any way would be all right.

Mr. GOLDIN. We had three options, A, B and C.

Mr. LEWIS. That is NASA had three options?

Mr. GOLDIN. There are three options NASA is exploring. One is the modular build up; second is a scaled-back of the existing Space Station; and the third is a new design. Each of those options will have different levels of costing. We may end up with more than three different costs.

We want to make sure that we know what the threshold value is in each of the options to incorporate our international partners. If we just stop at a specific cost number, I don't think we will be doing our international partners a service or respecting the American commitment to our international partners, unless we know the

cost number that takes us to full international participation. So, we will have those numbers.

INTERNATIONAL PARTNERS AGREEMENTS

Mr. LEWIS. I guess the reason for part of my question about A, B and C, and those numbers, is that I understand there was serious discussion among the Blue Ribbon Panel about those cost numbers, five, seven and nine billion dollars. It was generally agreed, when you get to the nine, that with that level of spending, the attached pressure module, APM, which is the European participation, and the Japanese experimental module, would not be aboard at that time, giving them very little incentive for participation.

How do you respond to that?

Mr. GOLDIN. I am not ready to accept that.

Mr. LEWIS. You, acknowledge that the Blue Ribbon Panel is discussing that?

Mr. GOLDIN. A number of our partners brought that up during discussions. We are going to have the costs for each of the levels for our international partners. Those costs will be presented.

Mr. LEWIS. Help me with our original agreement of understanding with those international partners. Am I correct in understanding that the initial understanding was that they were participating in a program that would lead to a permanently manned station?

Mr. GOLDIN. I believe so. I don't have the exact words of the agreement, and I may need some help. Mr. Schumacher, what is the precise wording in the agreement?

Mr. SCHUMACHER. I am not sure, sir.

Mr. LEWIS. My concern is this: It is my understanding that the agreement between the four countries, including the United States, was that all signers, were committed to a manned station.

Mr. SCHUMACHER. Yes, sir, that is my understanding.

Mr. LEWIS. That leads me to my next question, Mr. Director. That is: Is a fourth option, which involves a cost saving in construction and operations being considered that uses the present design? You may recall that George Brown, and I joined with others to sign a letter specifically indicating our strong belief that that was necessary.

Mr. GOLDIN. I think we are doing exactly what we said we were doing. I received Chairman Brown's letter. He asked us to consider a scaled-back version of the existing Space Station to establish that we could have management savings and associated savings and any other savings associated with it. That is our Option B.

We did review Option B, all the way through permanent presence. We have looked at each of the launchers required for that and we are establishing those numbers. So I don't believe we have violated the spirit of the suggestion that Chairman Brown and all the signees on that letter made.

Mr. LEWIS. Well, we might have some disagreement that may require some further discussion beyond this meeting.

In response to the Chairman's question, you indicated, when he asked what would be the cost to go forward over the next five-year period with the current design, that it would cost a little more or somewhere in the neighborhood of $2 billion a year.

Mr. GOLDIN. I didn't answer that question. Dick Kohrs answered that question.

Mr. LEWIS. How about you answering it?

Mr. GOLDIN. I don't know the numbers until we get them.

Mr. LEWIS. Your best guesstimate from your expert is somewhere around $2 billion a year. Multiply that by five. That takes you to ten.

Mr. GOLDIN. We are going to develop cost numbers to establish what we can do for $5, $7 and $9 billion. We will also have cost numbers available for what it would take to assure international participation. We will have that data available. I feel we have to have that data available in response to the letter that Chairman Brown sent.

Mr. LEWIS. One last question before I overextend my welcome, Mr. Chairman. You have been more than generous. But there is a feedback from the Blue Ribbon panel is of concern to me. If A, B and C, the three options reviewed last night, are not acceptable to our international partners, what do we do?

Mr. GOLDIN. We have been asked by the President to come up with solutions that will address the needs to the very best of our ability, of our international partners, and we are going to strive to do just that.

Mr. LEWIS. I am not sure we should have this hearing today. We are not getting much of a response.

I understand we are going to have another one in June, so that is all right.

Mr. GOLDIN. I don't mean to be unresponsive. We don't have the data yet. We just began the costing analysis today. I believe Mr. Kohrs has every right to make his estimate, but Mr. Kohrs is going to be working with the redesign team to come up with the cost estimates and we are going to have those cost estimates reviewed by the Blue Ribbon Panel. I feel uncomfortable in prejudging what the results would be; but I can publicly state that we will respond to Chairman Brown's request and make them available.

Mr. LEWIS. Thank you.

REDESIGN COMPATIBILITY TO THE INTERNATIONAL PARTNERS

Mr. STOKES. Mr. Mollohan?

Mr. MOLLOHAN. I just want to follow up briefly on Jerry's question on the station. What priority is the redesign effort giving to being able to have the redesign compatible with the international partners?

Mr. GOLDIN. That is a very high priority.

Mr. MOLLOHAN. So if you would elaborate on that by suggesting whether or not each of the designs will, in fact, accommodate the international community.

Mr. GOLDIN. We are covering completely those phases in the build-up process that incorporates our international partners. It is part of the process.

I personally have met with the lead people from each of our international partners. We welcome their open comments. This is not a closed set of design processes. It is open data. It is open to the public.

There is great anxiety on everyone's part. This is a very difficult process. Along the way, there are going to be tensions and there are going to be concerns. The reason I say this is when I talk to some of our international partners at the senior levels, we get one level of input. There is an anxiety on the part of our international partners that they are going to be excluded.

We will carry out what the President asked us to do. We will bring the data forward. All three design concepts have a design that takes us to full international participation and we will provide the cost data for those designs.

I do not know how much that cost will be, but we will have the cost data because that is what has been requested of us.

Mr. MOLLOHAN. The reason I ask is because I think a lot of people want to understand what role they will play. Dr. Gibbons, while testifying before the other subcommittee that I serve on, cited that our commitment to the international community was one of the driving reasons for his support for continuing the space station in some fashion.

You just indicated that you are "open to comments" from the international community. I am, of course, paraphrasing what you said. But, I take it that some of the international community are afraid that they will be excluded. Is that a fair summary of what you said with regards to the attitude of the international community right now?

Mr. GOLDIN. I believe there is concern on their part.

Mr. MOLLOHAN. It would certainly seem that at this point in the process they ought to know whether they are being excluded or included.

Mr. GOLDIN. They are not being excluded.

Mr. MOLLOHAN. Are they expressing concerns about being excluded?

Mr. GOLDIN. They have publicly voiced it.

Mr. MOLLOHAN. If you were going to speak for them, why would they feel that way?

Mr. GOLDIN. There is a great anxiety every time change occurs. It is a very complicated, difficult process.

Mr. MOLLOHAN. To what extent are they included in the complicated process?

Mr. GOLDIN. They are fully participating with the team at Crystal City.

Mr. MOLLOHAN. Would it be your judgment, having heard their concerns, that they are legitimate concerns?

Mr. GOLDIN. I am not prepared to establish whether they are legitimate or illegitimate concerns. I can only tell you what we are doing. What we are doing is looking at three different design concepts, all of which include options that take them through full international participation.

In the end, NASA will present the data. NASA will not make the decision. I want to make this very clear. We are going to be an honest broker who looks at three different design concepts, and provides the data to be reviewed by the blue ribbon panel; the White House will make a decision.

But we will have the data in terms of how much it will cost for option A, B and C to include our international partners.

PRESIDENT'S COMPETITIVENESS AGENDA

Mr. MOLLOHAN. The Clinton administration is focusing its attention and resources toward a competitiveness agenda. It has been a big part of their program presentation up here in a number of different areas. Federal entities such as the Department of Commerce have been targeted for significant increases to address our Nation's competitiveness issues.

There is increasing talk about the Federal Government bargaining with industry. It seems that the current administration is shifting the previous paradigm, if you will. I feel it is absolutely critical for NASA to position itself to play in this agenda now. I believe the issue is no less important than determining of NASA's role in the Federal Government in the post-Cold War period.

Mr. Administrator, would you please discuss how NASA is going to fit in the Clinton competitiveness agenda? With all due respect, I understand we have a new technology initiative in the space station line item, but that $2.3 billion has to go a long way. What I am trying to get at here is a systemic way that NASA will participate in Clinton's technology policy.

Mr. GOLDIN. NASA has a major activity going on right now looking at competitiveness. We have nine different committees taking a look at how we can interact with the broad range of interests. We are looking first at the aerospace community, the small entrepreneurial aerospace contractors, the minority aerospace contractors, the major technological universities that traditionally deal in aerospace, and the minority institutions that deal in aerospace.

In addition to that, we are exploring relationships with non-aerospace companies. We are exploring relationships with non-aerospace, non-institutional contractors. We want to reach out to get the very best technology that already exists to bring in to our NASA program and, at the same time, we want to take NASA technologies and get it into the industrial sector.

In the past we had more of a reactive approach whereby NASA would develop technologies and after we had done that, we would advertise in journals, such as Technical Briefs, and invite companies to come in and see what we had. Now we are intending to be more proactive and bring in the companies from the beginning. Toward that end, we have begun a series of meetings. The first one was with the chief engineers in the major corporations in the Aerospace Industries Association.

I indicated to them that as we move forward with our new programs, we are going to be looking at dual-use technology as equally as important as our primary mission focus. We asked them for ideas and concepts on how our contractors can bring in the nontraditional folks into the aerospace business, non-aerospace and all the other institutions I talked about.

We are talking about making this a part of the RFP process, so that when they bid on a job, they say we are going to respond to this mission, but we are going to align ourselves with the following companies who are not in the aerospace community, and here is how we are going to do it. We are going to ask them to make projections on what they are going to do. Part of the award process will be how effective they are in terms of technical transfer. When

we negotiate the award fee, a portion of the award fee will be assigned to how close they come to what they said they would do over the timetable. We also intend to measure how well they will do. I brought a few charts with me that indicate NASA has been very hard at work at this task. I have a chart here that shows the technologies that we have at the Jet Propulsion Laboratory and agreement JPL has with companies. You can see from 1991 to 1993 we went up from 62 to 130 companies. These are nontraditional companies that are working with the Jet Propulsion Lab to get technology transfer. We have a whole series of programs with them. This, by the way, was the number of projects we completed, technology affiliated tasks. Forty-five companies are actually working with us. They are asking them to start measuring in a very formal sense how we are reaching out to these companies.

This is a very serious program and we are taking it very, very seriously. We believe we at NASA will be the leaders in the Federal agencies on this initiative. We handed out a matrix. On this we tried to show how the NASA initiatives interact with the Council on Competitiveness Critical Technologies list which is listed on the side here. On the next page we took the Clinton-Gore strategy for critical technologies and we also showed where we believe we intersect. This assessment was formulated by the team in this room and these are the areas where we believe we can make a contribution to the tech base in the country.

Mr. MOLLOHAN. I understand NASA is participating in ARPA's Defense Conversion Technology Reinvestment Project. What is NASA's role in this program?

Mr. GOLDIN. I believe we are one of five agencies working with ARPA. We are part of a team that is defining a process to release requests for proposals to bring in companies for defense conversion. I believe we are holding a series of meetings around the country as an integrated government team. Each agency leads a meeting. We are leading one of the meetings. So we are working together with the other agencies to do the right things.

We believe by August, all of the proposals will be in and the selected companies will be in place.

Mr. MOLLOHAN. Is ARPA transferring funds to NASA?

Mr. GOLDIN. There will be a transfer of funds, yes.

Mr. MOLLOHAN. Do you know what number you are talking about transferring?

Mr. GOLDIN. I will ask Greg Reck to respond.

Mr. RECK. We are participating with the other agencies in selection of proposals. There is no formula for predeterminating the portion of funds to be given to each agency. After the proposals have been selected, the team will sit down and determine which agency is in the best position to execute a specific proposal. At that point the funds will be transferred. If one of the other agencies besides ARPA is selected for a proposal, the funds will be transferred to that agency and that agency will be selected to do the program.

Mr. MOLLOHAN. You do anticipate funds being transfered from ARPA to NASA?

Mr. RECK. We do expect that they will, yes.

Mr. MOLLOHAN. Have you talked about an anticipated figure?

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Mr. RECK. No. We will not consider any of the transfers, how many proposals or how much research will be transferred until after the selection process has been completed.

Mr. MOLLOHAN. That is interesting. Commerce already has their territory a little more staked out. They are talking about a little over $150 million of the $500 million.

Mr. GOLDIN. NASA is trying to operate as a team member. I say that in a very positive sense. I don't want to make any other comment on other agencies. As we go into the future, if we have separate pools of money for every agency which each would have ownership of, I don't know what will happen. What is really the important factor here is that we work together as an integrated team in the government. That is where we are at NASA. Wherever we have an appropriate contribution to make, we will make it. Our desire is not to get more funding for NASA. Our desire is to be effective. If we are effective with a smaller percentage, so be it. We are not going to view this as a report card for NASA.

TECHNOLOGY INITIATIVES

Mr. MOLLOHAN. On one hand you mentioned cutting risk in your programs and on the other hand you are trying to reduce the development time for your programs. I applaud both goals, but they can be quite inconsistent goals. I would like you to reconcile them and explain how you are going to keep both for NASA.

Mr. GOLDIN. We will not achieve both on all programs. If we will undertake our technology initiatives, we have a set of four very, very bold programs. There are four potential new start programs in the space area in our technology initiatives that will use cutting edge technologies. In fact, one of them we call "Tech Sat" where we intend to do very non-conventional things in terms of contracting arrangements where NASA might just end up buying a data service. We want the contractors to use very new technology. We want to do that in a few years, not a decade.

Another area where we are going to be on the cutting edge is aeronautics. That budget is up 18 percent from last year. We have a broad range of initiatives that takes America to places that other countries won't be for years.

So in those areas we are going to be very aggressive and very bold. In other areas where we have had ongoing programs for a number of years, we cannot suddenly change and go to a new technology after we have been underway for a number of years. So we may not be able to do it for all programs. But wherever we can, as we start new activities, we are going to try to initiate bold new initiatives.

MOON/MARS EXPLORATION

Mr. MOLLOHAN. I think it is clear that the current administration is not committed to sending man to the moon or mars. It is not a high priority as I understand it. So, where is the agency headed for the long-term?

Mr. GOLDIN. Could you give me a sense of what you mean by long-term time scale?

Mr. MOLLOHAN. Well, you give me a sense of what you think in terms of long-term. What would be a long-term vision?

Mr. GOLDIN. Thirty to 50 years from now.

Mr. MOLLOHAN. What is short-term?

Mr. GOLDIN. Five years.

Mr. MOLLOHAN. Then I'd like for you to speak to the somewhat long-term.

Mr. GOLDIN. NASA will explore the solar system with humans and robots. NASA will have a very, very bold program to search many other galaxies of our universe for planets. On those planets we will search for signs of oxygen and carbon dioxide to see if there is an environment that might be conducive for life forms of the planet Earth.

In the long-term, those are the type of things we are going to be doing. But for now, it is not appropriate, nor do we have the budget, nor are we ready to undertake an exploration of our solar system. NASA must be put on a solid budget ground. If you take a look at where we were in planning for the Space Exploration Initiative, it was much too expensive over too long a period of time.

We have to understand what technologies exist and what people are working on those technologies. Time is a precious technology. With time you can develop understanding. I think it would be good to explore that goal five years from now and to see where we are.

Also it doesn't make sense to explore the solar system until we know if humans can live and work under zero gravity conditions.

In the long run, I believe the exploration of our universe with humans and robots is where NASA is going.

Mr. MOLLOHAN. Thank you, Mr. Chairman.

INTERNATIONAL PARTNERS PARTICIPATION/SPACE STATION REDESIGN

Mr. STOKES. Before I yield to Mr. DeLay, Mr. Administrator, let me try to clarify something from the subcommittees' perspective that is a follow-up to questions posed to you by Mr. Lewis and also by Mr. Mollohan. That is, if you do redesign the station and you do accommodate the international partners but in order to do so you cause the U.S. lab to be power short, that is not acceptable to the committee because it makes no sense to us to spend $5, $7 or $9 billion on any station and not be able to meet NASA's commitment of the 11 kilowatts to the U.S. lab.

Does that make sense to you that you cannot meet that requirement?

Mr. GOLDIN. I am not ready to make that concession.

Mr. LEWIS. Mr. Chairman, I think you make a very good point. I certainly don't want to imply, Mr. Administrator, that the international partners are my only concern in this fix. If this station is not designed in a fashion to have us as a presence in space that involves mars, most of the science would be diminished. It could be done more cheaply here on earth.

I hope you did not make concessions that involved modifying the values of the United States in our future efforts by way of satisfying our partners.

Mr. GOLDIN. Mr. Lewis, we must have an effective Space Station first. When you asked me about our priorities, I said among our

priorities is satisfying our partners; but if that is all we do and don't satisfy the people in the United States, I don't think we have a program that is of value.

I think one of the major research areas for the Space Station will be physiology in zero gravity to understand how we can develop countermeasures for exploration, which I deeply believe in. I believe in exploration. I believe many in NASA do. But there is real fall-out from that, I believe and many of us in NASA believe. I can have Harry Holloway come up here and talk about it, but let me summarize. By studying normal physiology in an abnormal environment, by studying the interaction of the human physiology when exposed to zero gravity, the knowledge base we gain will complement what we know on earth. That will lead to very, very significant improvements in the medical industry in this country. It will lead to, we believe, significant understanding and improvement in preventative medicine. As an example, I point out when you go out into zero gravity, you lose bone mass, you lose muscle mass, you lose fluids, you lose balance. You increase the amount of calcium in your blood stream and build up kidney stones.

If you take those five items and look at what happens in aging, the knowledge that we will gain by having zero gravity in space and measuring the exposure of humans to zero gravity will be very beneficial to understanding the aging process.

Mr. LEWIS. I wanted to be sure I did not mislead you by my questions. I think you also should understand that NASA has very substantial support in the House. That's been demonstrated on more than one occasion. But that support involves the House's commitment to that pioneer spirit.

SPACE STATION REDESIGN

Mr. STOKES. Mr. DeLay.

Mr. DELAY. Thank you, Mr. Chairman. Mr. Goldin, let me go straight to the report that I have not established especially with the subcommittee. It is no reflection on you. You have a directive you are living under and I understand that.

I need to express the frustration that my constituents are expressing to me and certainly I share their frustration. I have to tell you, I think this whole redesign thing is just poor administration, poor management. You have a space station that has been scrubbed and scrubbed and scrubbed. It has survived opponents' attempts to defeat it on the Floor of the House and the Senate because Members are representing their constituents and their people are really expressing their support for a space program. I can't for the life of me understand why you would come back in and do this. It is really irresponsible.

The directive is irresponsible and it is exemplified by the questions from the Chairman and the statements by the Chairman and the ranking Member and the other Members on this committee.

What we are hearing from our international partners is the erosion of support in their countries. People who have not supported space in those countries are gaining momentum due to the undermining that is going on in this country.

The same thing is happening here. I am seeing it among companies where companies now think that they can start pulling out on their own and competing for a particular option which is undermining our total resolve for this space station and therefore the space program.

We have to deal with it. From the very beginning, I suggested but did not get a lot of support, that we pass a resolution for a sense of Congress, nip it in the bud right now and see where the votes are.

My colleagues did not seem to want to do that. They wanted to go through this process. Maybe in the end we will see that it is very helpful and very eye opening.

You have the Vice President coming to Houston saying there will be a space station and we support it and at the same time this directive undermines it. I think it is unfortunate, what is happening.

From the start of this redesign effort it has been clear to me that the administration is concerned with the costs. It seems to me you could look at the costs and scrub it and see if the space station is in the President's plan for the future of this country.

There are several things that really concern me. I won't take up the committee's time with all of them. But there are a couple of them.

It seems to be, at least, that the mission of the space station is secondary to the cost. That is what I seem to be hearing.

It has come to my attention that some of those involved with this redesign feel that it is a futile effort and some of those intimately involved with the project believe this exercise is cost driven, instead of being created in response to mission requirements.

Some are at the point of considering resigning from the redesign effort. While some in Congress may feel I am somewhat conservative in my approach to Federal spending, I can assure you that I certainly don't like spending money for a half-baked idea.

I know you have answered the same question over and over again, but I will ask it in a different way. I can assure you this committee has in mind, in this project, the mission first in its effort to find an answer?

Mr. GOLDIN. We will not propose a design that does not meet the mission objective. The whole purpose of it is to provide a 10th laboratory in space.

I believe it is crucial to the future of this country. If we do not build a Space Station it will be a crime. If we do not build a Space Station, we are going to be sending a signal to the world that we are no longer a space-faring nation, that America is backing into the past. It cannot be. We must have a Space Station.

If we don't have a space station, our credibility is going to be devastated on a worldwide basis, and I anticipate that we will see new partnerships developing in this world that will exclude America, today and in the future.

Mr. DELAY. Maybe I am just a dumb bug killer from Houston. But, when I see Option C, what I call "Man in the Can", I don't understand why it is even an option. It just boggles my mind.

Is it just so we can have something to talk about? To me, a man in the can doesn't do what you just said. Maybe I am showing frus-

tration to my ranking leader. That was a fascinating response. But are we going to put mission first or put cost first?

Mr. GOLDIN. We cannot launch a Space Station that does not do anything. We must have a meaningful mission.

Mr. DELAY. President Clinton has been talking about a space station since the campaign. He was in Houston, but the President has forgone what he outlined at that time. Can you tell me what this administration's space policy is and how this space station fits in that policy?

Mr. GOLDIN. From a procedural standpoint, I believe the White House is in the process of drafting a comprehensive space policy. I anticipate it will be released in the very near future.

I would feel it would be inappropriate for me to prejudge the position that the White House is going to take. But I think it may be coming out next week.

MANNED SPACE STATION

Mr. DELAY. Let me highlight one of the rumors. We have forgone not only the initiative but now it seems like we are projecting to move away from a balanced approach of 51 percent manned space, to 49 percent unmanned space in five years, to a 40 percent manned and a 60 percent unmanned space effort. That is only possible if we end up spending the most optimistic amount of $9 billion on the space station.

Can you tell this committee what the policy is toward the manned space station and why then this large shift in emphasis?

Mr. GOLDIN. We do need a balanced space program in this country. I just took a look at some of the numbers today back from 1991, of the projected shuttle costs. If you take a look at those numbers and take a look at where they were to go, and take a look at some of the numbers in this budget, I don't believe we have taken any value from the human space flight program with the efficiencies we have incorporated in the shuttle program. As a matter of fact, I believe we have a much stronger and better program. I think it is going to contribute to the overall program. If you take a look at what we had been doing in the robotic area of the space budget, we had been narrowed down to a very few big programs and we were not doing bold and broad things that could serve as a precursor to human space flight.

I know in the new budget when you take a look at some of the things we are talking about, many of these things are precursors to what could happen with humans. We are looking at a very bold mission called, MESUR Pathfinder (Mars Environmental Survey), which would measure the surface of Mars. This mission is 5 percent of the cost of Viking. Does it make it any less valuable? I don't believe so. Because we are designing this mission to cost and we are using bold, new approaches because cost is also a factor in the process. Instead of using a lander that goes down on the surface of Mars with retrorockets and very complicated systems, the brilliant folks out at the Jet Propulsion Lab are going to send a spacecraft directly to Mars. A balloon will come out, a parachute will come out that will help it land. Then air bags will open up and we won't need retrorockets and it will roll over the surface. Then the whole

spacecraft will open up and a little robot will roll out and start sampling the surface of Mars. I think that is darn bold and I think that is exciting.

So we are going to have reprioritization. I don't think it takes away. I think we have a good sound program and we are focused on where we want to go—that is toward advanced technology and an understanding of our solar system.

Mr. DeLay. Are you saying you are supporting the 40-60 split?

Mr. Goldin. I have not looked at the numbers as percentages. But we have submitted a budget, and if those are the numbers, yes.

NASA MANAGEMENT STRUCTURE

Mr. DeLay. Let me turn to management. Mr. Goldin, you expressed concern earlier in this hearing and elsewhere that the current NASA management structure needs to be revamped. One emphasis is the redesign effort. I understand the proposals put forward by the aerospace industry that pointed out the overriding costs of the space station was management, not hardware.

If I remember correctly, this analysis computed that 76 percent of the costs of building Space Station Freedom came from management alone. Can you inform us as to what some of your findings are so far and where you think NASA can focus on costs while maintaining the current Space Station Freedom configuration?

Mr. Goldin. Those numbers were prepared by contractors. Twenty-four percent was in hardware, but I don't believe the remaining 76 percent was in management. It is a documentation of the variety of other things we do. A good portion is in management, and I believe it is worthy of restructuring. We have taken the first step.

Walt Brooks, who is from NASA Ames, is in charge of the management committee. He came up with five different approaches to management. Some of them are so painful to the existing management structure that some of our Center Directors have threatened him. I told you we were going to break rice bowls. We cannot have it both ways. We cannot make people happy and do what is right. We are going to come up with these proposals. I believe the most important thing will be to fix the management. I seek your support when we do it.

I think there will be a level of pain. I am embarrassed that some of the managers who work for me threatened Walt, but you know something, they are no longer going to be here.

Mr. DeLay. Thank you.

SPACE STATION SUPPORT

Mr. Stokes. Mr. Gallo.

Mr. Gallo. Thank you, Mr. Chairman.

I think as you get down to the third individual, a lot of the questions that were on my mind have been answered.

One of the things that concerns me is the competitive nature of this overall program and the role of the international community. I see this not only with NASA programs but with other programs where we have international involvement. There seems to be a lack of confidence by our international partners and a lack of participa-

tion in our programs when the United States is unwilling to follow through on our commitments. The international communities have almost contributed $2 billion in this program already.

I can assure you that no matter whether there is support from this administration, it is going to be a difficult task on the House Floor and the Senate Floor and this is only compounded when you start redesigning.

A redesign at this stage, I think, seriously erodes a lot of the support that the space station can have.

I think it will be very difficult to convince people that you are going to be able to do the same thing, that you were so excited about that last year with a redesign which means a reduction in overall scope.

I know those that have supported the Space Station, including myself, are going to have their hands full trying to convey to our colleagues that we have a project that makes sense and should go forward. You know that fight is going to be a tough one.

This has been asked a number of ways, so I will just ask it straight-out. Do you think as a result of this redesign that we have lost confidence from the international community?

Mr. GOLDIN. I hope that is not the case. Let me provide some perspective here. I met with the Minister of Science and Technology from Canada. I had a long discussion with him about this whole process. It was a very interesting conversation. When he came in, he was looking at it from the direction of the United States might not be interested in the Canadian activity.

I said to him, you know, we made a decision some decades ago that committed the United States to utilize Canada in our robotics activity. If we wanted to today, we could not replicate that activity for perhaps 10 years, so as much as they need us, we need them.

There are a whole level of people when you talk about the international community. You have the very senior people in the international community and you have some of the people that are working on the existing system. The people working on the existing system have tremendous anxiety. By the way, the comment I made about Walt is not just in NASA. Some of the people on the redesign team are being "beat up" by the employees and managers of the existing Station program because they are part of an existing system. We cannot have change without frustration and anger coming out. It is a healthy human expression.

But the fact of the matter is, either the United States is going to meet its international commitments and put up a Space Station, or we are going to fail. I cannot conceive of the space agency without a Space Station. I cannot conceive of running a space agency without a Space Station. Because without a Space Station we are not going to have a human space flight effort and without a human space flight effort as a program—Mr. DeLay talked about 60–40, the thought of 0–100, is just appalling to me.

What we have to face up to here sir, and I understand the concern you have, we have to come together as an industry, an agency and a country and decide we want a Space Station. If we don't do that, our credibility with our international partners will be severely damaged, not just in space, but affected all across the whole

broad technological range. I don't know who will want to work with America.

ACADEMIC PROGRAMS

Mr. GALLO. That leads to the other question. Even when there are glitches, and there seems to be a change in direction that has a very adverse effect to staff and the talented people that you have working on a project. As soon as they start to feel there is a changing commitment which may be a response to either Congress or the administration, we lose very brilliant people.

I know that happens, not only in the space program, but it also happens in other programs. The other subcommittee I am also on, also experiences these problems, when there is a lack of commitment or at least a perceived lack of commitment it has a very, very serious effect on the scientific communities.

Let me ask about one other area that I found exciting. It is a small portion of the budget but it is the academic program. The amount that I see for last year was $92 million. That has been cut to $74.5 million. If we are going to continue to whet the appetite of young people in the scientific fields, I don't think we should reduce this very worthy program.

I know just your visit to the campus of Drew University was so well received by the students. To get people interested in this area of study, it is important that they have the kind of contact and understanding of what can happen.

In New Jersey, we don't have a big NASA complement but we do have some very bright students who are interested in all types of educational opportunities. I am curious to learn what your explanation for this cut and what the ramifications are?

Mr. GOLDIN. The explanation, as it pertains to NASA's education budget, is that there were $19.4 million of special projects that were added to the budget in 1993, earmarked in the budget. They were one-time activities that were put in 1993. We have funded them and they are in place. They just were not picked up in 1994. That is where that change occurred.

Mr. GALLO. That is Mr. Goldin, still a $21 million reduction.

Mr. GOLDIN. I look at it differently. In 1993, there was a set of funds put in on a one-time basis. It put a kind of a blip in our budget as we went along.

Mr. GALLO. You are saying the $74.5 million is a constant factor that took place outside of the blip that took place on two projects?

Mr. GOLDIN. Yes.

Mr. GALLO. I just want to reemphasize how important that part of the program is, not necessarily the amount of dollars, but what it means to getting our young people involved. In many cases, we are losing young people to other areas, whether it be computerization or things of that nature. I want to make sure that you have an intelligent, diversified group with expertise, who will be going on to other specialties.

Mr. GOLDIN. You are absolutely correct. As part of the Technology Initiative package, we are proposing increases in research amounts at colleges and universities. It is a significant amount of money. I have met with some of the university people and they told

me some of the terrible problems they are having, so we identified research and analysis funds to go there. In addition to that, as part of the institutes we are proposing, we are asking universities large and small, minority institutions, and American corporations to come together, and as part of that process, to make education one of the critical technologies that we transfer with the movement of human beings.

When we come back the middle of June and show you our budget, I think you will see an increase in this area of the budget. At that time, we will be prepared to give you a specific input on the budget, but you are absolutely correct.

Mr. GALLO. The other area where we will have an opportunity is in defense. For those companies that have high-tech responsibilities, I think if you talk about transfers of technologies, it is much easier to transfer that technology or that capability into space programs or other high-tech programs, rather than some other programs that are being proposed.

Thank you.

Thank you, Mr. Chairman.

CONTRACTOR PROBLEMS

Mr. STOKES. Thank you, Mr. Gallo.

I want to follow up just a little bit on the dialogue between you and Mr. DeLay and the contractor problem.

Back in January, when I assumed the Chair of this subcommittee, I was concerned that part of NASA's problems were due to micromanagement by the Appropriations Committees. I asked Dick Malow to prepare a staff memo for me tracing this whole history back a little bit.

I just want to read from part of that staff report which to me, bears upon what you have already said here today.

The portion I want to read is as is follows: "It was the Appropriations Committee that first recommended that the management puzzle which tended to foster overhead excesses had to be fixed. On October 18, 1989, the fiscal year 1990 conference report observed, "that the House committee surveys and investigations staff report, suggests that both NASA personnel and resources committed to management and integration activities are excessive."

Also, the report says that, "NASA center officials and contractors believe that level two Reston involvement and systems engineering and integration have unnecessarily increased Space Station program costs."

That message was reinforced on September 24, 1992, in the fiscal year 1993 conference report. "The conferees continued to be concerned that a disproportionate share of the space station funding is devoted to overhead costs which currently constitute more than 50 percent of station resources. Therefore, the conferees direct that NASA should consider alternate approaches to reduce these costs. In that connection, the conferees strongly urge that the agency examine the possibility of collapsing the existing contractual arrangement into a single prime contractor and with a single lead center in order to strengthen program execution and accountability."

The staff report says, "Call it micromanagement, if one wants, but these overhead directions are reflected in the committee meeting its fundamental oversight responsibility and the recommendations were and remain on target."

In fact, four months later, Vice President Quayle in the Space Council indicated in their final report that, "To contain costs, overhead should be reduced by consolidating management responsibility within a single NASA center by assigning a single contractor with overall responsibility for program integration. Unnecessary supporting activities should also be cancelled."

I think it is important that this be made a part of the record since the committee has for this extended period of time expressed these type of concerns, which obviously you agree with.

Mr. GOLDIN. Let me say for the record that this Administrator does not believe NASA is being micromanaged by the Committee. This Administrator believes the Committee is giving NASA very sound management advice.

NASA HEADQUARTERS STAFFING

Mr. STOKES. We thank you. When you became Administrator, I think it is fair to say you were concerned with the level of employment at headquarters. That is also one concern that the committee has expressed in various ways over the past five to seven years.

What has caught our eye is the fact that in fiscal year 1984, there were a total of 1,306 on board, full-time personnel at headquarters. At the end of fiscal 1992, there were 1,711 FTEs on board, including approximately 157 contractor conversions.

In addition, on September 30, there were approximately 25 NASA employees detailed to headquarters from other centers. Now the total of 1,711, as the number indicates, is substantially higher than the numbers in 1984.

Would it be a fair and reasonable goal to achieve reduction in NASA headquarters staffing by, say, five percent in fiscal year 1994?

Mr. GOLDIN. The answer is that I believe our plan has 4.3 percent in fiscal year 1994 at Headquarters. That target was established before data from the roles and the mission study that Jack Dailey will be reviewing over the months ahead. I believe we will come awfully close to that 5 percent, but we are not stopping there. We are looking out at 1995, 1996 and 97. We are trying to be sure we have a clean understanding of the roles and responsibilities at Headquarters. These are not bad people at Headquarters. We want to be sure we treat each human being with dignity and be sure they have a proper role to perform as they transfer out of Headquarters, and try to make sure they don't have a great big disruption in their lives as they transfer out.

So we are trying to factor all those things in the process. But we will strive to come as close to 5 percent in FY 1993 as possible. But right now we are at 4.3 percent.

CENTER OVERSIGHT

Mr. STOKES. We wanted to talk about the overall question of how NASA is staffed and what we perceive to be one of the problems.

In some of our discussions with aerospace contractors a kind of theme has emerged that we would like to get your reaction to.

Contractors are telling us that there is simply too much of what we might call "center oversight" of NASA employees of various NASA programs. We have heard of two or three occasions where the programs would be perfectly willing to accept a fixed-price contract, but the center is opposed to that approach and insists on a cost-plus contract.

We realize that a fixed-price contract can be just as troublesome as a cost-plus contract. But just for a moment, the information we are getting is that the contractors prefer cost-plus so the center has a much more involved role in the day-to-day execution of that contract.

According to some of these contractors, that role is reduced dramatically under the fixed-price approach. It would seem then that perception is at least partially accurate that some of the NASA centers are overstaffed and we need to be thinking about how we address that problem. What is your reaction to those remarks?

Mr. GOLDIN. Let me first speak as an ex-contractor. I was very frustrated as a contractor because, on one contract that I know of, NASA had more people on the job than the contractor. And when we had reviews we had more NASA employees than contractors come. That is not to say that the NASA employees that came were bad. The system was bad. The approach was bad. Because, unfortunately, in many circumstances NASA is viewed as a jobs program. This is not just an issue of the NASA employees. It goes much broader than that. In order to change it, I think it is more than just changing from fixed-price and cost-plus contracts, to how NASA is managed and how it is viewed. Again, it comes back to a statement I made that if we are going to make changes, we are going have to have a broad range of support when we go to make those changes, so it is recognized that jobs exist in America because NASA is there. People don't have jobs just because they work for NASA. That is the fundamental issue we have to come to grips with.

As part of some of the initatives points we are looking at—I made specific reference in my introductory comments—it is my intention to channel the funds to the contractors. There is nothing that can be done if you have a bad contractor. A bad fixed-type contract can be worse than a cost type. But we have to respond in a very different way. That is the change we have to make at NASA.

I view the change we are going to have to make in the Space Station as a watershed in terms of how we are going to manage at NASA. I cannot disagree with the intent of what you said, but I do believe we have to make a change again, not because the NASA employees are bad. We have to have the NASA employees working on important things.

Let me tell you, I know that the redesign is taking tremendous criticism. But I was down at NASA-Johnson on Saturday and I met with 60 of the most turned on human beings that I have seen in a long time. Why? Because those NASA employees, without the help of service support contractors, were being asked to be technical and to come up with a Station redesign. In the period of time these

folks had with me, they demonstrated to me they are as good as any Apollo designer in the world. I told them how proud I was of them. You could feel the energy in the room. Instead of managing other people's work, instead of having contractors do the work and managing their work, we had only NASA people. Ninety percent of our work is contractor, so we certainly have some flexibility for creative work by NASA employees. And I think that is the direction we need to go in.

HEADQUARTERS/JPL MANAGEMENT

Mr. STOKES. As a follow-up to that, another problem we may have to face at NASA is how to meld a rather inflexible Civil Service and perhaps an even more inflexible Senior Executive Service with what should obviously be a very dynamic and fluid employment capability as NASA manages these ever-changing high-tech programs.

In short, it seems as though the JPL model where the employees for all practical purposes can be removed, or let go, or promoted without regard to Civil Service regulations, may have some advantage. It would seem that the JPL model allows NASA to constantly be reinvigorated with new blood and able to respond to change. What are your comments on that?

Mr. GOLDIN. Mr. Chairman, I think that is a suggestion worthy of some very serious thought. The Augustine Panel had asked NASA to look at that. I read the Augustine Panel report. Over the last two or three months, we have been considering the possibilities of some preliminary analysis along those lines. As our thoughts develop, we could share that with you. I don't know that we could suddenly do it. I don't know what the costs are. JPL came into the system. I don't know what the transition costs are and whether we have money in the budget.

But we have some NASA centers that I believe are Centers of Excellence. It might be worthy of looking at some of those centers in that light. So I will take that on as a very serious action.

SPACE STATION RESERVES

Mr. STOKES. It is my intention to move into budget questions. Are there any more general questions?

Mr. Lewis?

Mr. LEWIS. Mr. Chairman, my initial question is not a budget question. In discussing reserves, you talked about $100 million the first year, $150 the second, and $400 million the next?

Mr. GOLDIN. I didn't say that. Dick Kohrs said that. Let me also say, I don't accept $100 million as an adequate reserve.

Mr. LEWIS. During the budget hearings we had earlier, you specifically responded to a similar question. You said you felt we had to front load the reserves rather than operating on a wish list.

Mr. GOLDIN. You are right, sir.

Mr. LEWIS. In response to Mr. Gallo's question, it seems to me that after about the fourth go-around, you got to the point of saying "a manned presence in space," and I took that to mean, "maybe even looking at Mars." Without that there is not much reason to have NASA. You came very close to that.

I know we are trying to redesign our definition of your mission. I know that we have very serious dollar pressures in this difficult year that leads us to the redesign. Far be it from me to suggest that politics should affect this process, and I know that downtown they would never consider politics, but it occurs to me that some of our friends are consulting with the Russians as well.

Wouldn't it be a strange circumstance if we found ourselves in the position where our int'l partners along with the Soviets found themselves with a manned space station and we were somewhere out there playing with something else? It would not have any political fallout, I'm sure, among the American public, but we in Congress would be concerned about it.

Mr. GOLDIN. I would cry as an American.

HIGH SPEED RESEARCH PROGRAM

Mr. LEWIS. Maybe someone ought to hear it somewhere, downtown. Two of the themes in your briefing to the press about the details of this year's budget, were that it needed to be more balanced and that NASA's programs needed to be more relevant to the American people.

Sometimes NASA is referred to only as the space program. That ignores efforts in another area.

Let me ask a couple of questions. Fiscal year 1994 marks the transition from Phase One of the high-speed research program in which you determined that the environmental problems associated with the ozone layer noise and the sonic booms can be successfully addressed, to Phase Two. In Phase Two, you propose to develop the critical technologies such as the propulsion system and the air frame materials. I want to make sure that we understand what moving from Phase One to Phase Two could mean for private industry in country. Is it accurate to say that you have determined that America will be at the forefront of a second generation SST?

Mr. GOLDIN. Without a doubt. I am not afraid to say the word SST. America always set the level of the playing field in aeronautics, and then people started to climb up to our levels. And for the last 20 years, we have been slogging it out in the mud on the same playing field with everyone else. I propose it is time that America get bold. Our President has supported this initiative, to step up and set a new level of the playing field and not worry so much.

It is a risky program. We cannot guarantee it will succeed, but I want to tell you, I personally met with the CEOs and the leading executives of our major aeronautics companies. I met with the National Research Council. I met with leaders in the university community. They all believe that there is a very good chance that we can pull this off. And if we do, we could capture this market for 500 to 1,000 planes. It will be one of the toughest technological challenges we have ever undertaken as a country. But this time will be different than in 1969. In 1969 to 1971, when the Europeans came out with the Concorde, we walked off the playing field and let them set it. Now it is time for us to set the level of the playing field. Like a potential loss of a Space Station, this is another area where we cannot walk away.

Mr. LEWIS. If we do this right, you suggest we are talking about between 500 and 1,000 planes and achieving international sales of some $200 billion. Some suggest it would create as many as 140,000 new jobs?

Mr. GOLDIN. Yes, sir. I think it is risky but I think we have a very good chance of making it. We are all working together as a team.

Mr. LEWIS. Aside from whether Congress has the ability to give you the $1.5 billion over the next eight years, what else can you think of that would allow us to lose this opportunity to the Europeans or Japanese?

Mr. GOLDIN. Fear of failure could cause us to lose the opportunity. During the course of the discussion we have had over whether or not we should go for a High Speed Civil Transport (HSCT), a number of people have said, why don't we stick with what we have and improve it a little bit, because if we take this program and fail, it will be embarrassing. This is not the way America used to act. This is symptomatic of the things that have set in our society, where we always want to make sure that we can guarantee results before we start. We cannot guarantee results on this program. I think this is going to change the tide.

The other thing I want to point out is that the technology that is going to come out of the High Speed Research Program is going to be very broad-based. It is going to help the sub-tier suppliers that support our aeronautics industry. It is going to develop new materials that could be used in a broad range of areas—New approaches for cleaner and quieter engines that can also be applied; New approaches to the glass cockpit. I think it will be very beneficial to us. But I am afraid that we have become so wedded to guaranteed success that that could really hurt us badly.

Mr. LEWIS. Mr. Chairman, as I may have mentioned earlier, the Chairman of the Defense Subcommittee has called an emergency meeting at 11:00, and I must attend. I have more questions.

Mr. STOKES. They are going to be with us for a couple of days.

Mr. GOLDIN. We will be here for two days.

Mr. STOKES. We will recognize you when up come back.

Mr. LEWIS. I will be back soon.

PAYLOAD OPERATIONS AND SUPPORT EQUIPMENT

Mr. STOKES. Let's turn to page RD2–12, under Space Transportation Capability Development, and specifically payload operations and support equipment.

On that page you note that $95,400,000 includes development of an external airlock that will be used on shuttle to support docking with the Russian Mir in 1995.

What is the total cost of that external airlock?

Mr. ALLISON. It is $11 million in 1992 and $36 million in 1993.

Mr. STOKES. Total cost is 36 million?

Mr. ALLISON. $47 million, sir.

Mr. STOKES. How about 1994?

Mr. ALLISON. It is finished during 1993.

Mr. STOKES. Of the $95,400,000, how much is dedicated in fiscal year 1994 to the airlock, how much in 1993, and what if anything from the 1992 funding?

You also indicate that same airlock is an operational requirement for the space station.

Mr. ALLISON. That is correct.

Mr. STOKES. Regardless of which option is selected under the redesign, will they all require this external airlock?

Mr. GOLDIN. I am not sure, we will have to get a written response to that.

[The information follows:]

EXTERNAL AIRLOCK

The external airlock/docking system is required to support mating the orbiter with the space station and is required for each design option being considered. The configuration also provides a pressurized crew transfer path from the orbiter to the space station and an airlock for conducting orbiter based EVA operations.

Mr. STOKES. Was the cost of this airlock ever carried under the space station budget?

Mr. ALLISON. No, it was not.

ADVANCED TRANSPORTATION

Mr. STOKES. On page RD2-14, under Advanced Programs, we note that the line advanced transportation has increased from $9.5 million to $18.4 million.

Are any of these funds targeted for any NLS or "spacelifter" activities? If so, how much?

Mr. ALLISON. No, sir.

SOLID PROPULSION INTEGRITY PROGRAM

Mr. STOKES. The Solid Propulsion Integrity Program (SPIP) is requesting $11.6 million. What is the total cost of that program and how much have we spent to date?

Mr. ALLISON. It is an ongoing program, Mr. Chairman. I would have to get how much we have spent to date for the record, but it is supposed to continue on.

Mr. STOKES. Just provide it for the record.

[The information follows:]

SOLID PROPULSION INTEGRITY PROGRAM

The Solid Propulsion Integrity Program (SPIP) was established in 1985 to enhance the Nation's engineering database for solid rocket motors and thereby improve their success rate. This program has created, and continues to upgrade, an urgently needed engineering capability for improving the success rate of U.S. solid rocket motors. One of the SPIP's major successes have been the cultural shift within the solid rocket motor industry. Through SPIP, NASA has developed a Government/Industry team which freely exchanges data and information, identifying the principal problems which have plagued U.S. solid rocket motors and coming up with solutions to these problems.

Private sector ELV manufacturers are infusing initial SPIP technology products into their programs. A new nozzle material has been demonstrated as a potential replacement for Rayon; one of the important benefits of this material is that it can be manufactured in a more environmentally acceptable manner than the Rayon. The SPIP program has developed databases that catalog the nozzle materials and propellants used by the commerical sector, NASA and DOD.

Non-Aerospace applications for SPIP technology are also emerging. The X-caliper, a measuring device, has immediate application for ELV manufacturers and further

use in process and quality control in other arenas, such as the aircraft and electronics industries. Automotive and other industries are showing interest in new contamination and thickness measurement technologies that are being applied to solid rocket motors. Similarly, petroleum and airplane manufacturers are pursuing nondestructive inspection and measurement technologies developed within the program.

By the end of FY 1993, the SPIP will have spent a total of $83 million. The FY 1994 SPIP request is $11.6 million. SPIP is an ongoing program which continues to provide critical engineering for solid rocket motors; therefore, there is no total cost for SPIP.

NEW LAUNCH SYSTEM

Mr. STOKES. On page RD2-17, the NLS budget is displayed. There is no request for 1994, and as the table indicates the request for 1993 was reduced to $10 million. This program has essentially been cancelled, although the committee did provide $10 million for continued work on a new engine.

Has that $10 million been allocated to engine work, particularly the STME?

We note that there is no request in 1994, does that mean that there is no funding for engine work?

Mr. ALDRICH. Yes.

Mr. STOKES. We note there is no request for 1994. Does that mean those might be requested in some other line item?

Mr. GOLDIN. We have identified a series of tasks we are going to look at for advanced access to space. We are in the process of defining that right now. In June, when the President submits his final package for NASA, we will identify where those funds will be spent. It is our concern right now that the United States needs a new launch capability, but it is not clear to us that the National Launch System is the approach to undertake. We will be getting that data by June.

RESEARCH OPERATIONS SUPPORT

Mr. STOKES. On page RD2-19, the Research Operations Support budget is outlined. You are requesting $149,800,000 for that activity.

This line item is repeated under two or three additional areas within the NASA budget, and is the direct result of the action taken in fiscal year 1992, which removed what was known as "fund source three" from the salaries and expenses appropriation and spread it throughout the research and development and space flight accounts.

There was a great deal of debate that went on concerning the rightness of wrongness of doing this, but in the end, NASA asked the committee to proceed and make this change. The thought was at the time that by comingling the former fund source three monies with the program monies, it would give the center directors substantially more flexibility to enhance fund source three activities.

The question we have is, has the concept worked, or is the fund source three piece of the budget pie being pinched as much as it was when it was under the old account?

Mr. ALLISON. The concept has worked. We have been able to move money into those accounts. We have three in Research and Development (R&D) and one is Space Flight Control and Data Com-

munications (SFCDC), Mr. Chairman. We have since that time restructured those accounts to take the direct funding or benefit programs and transfer programs out. That was completed in our operating plan this year. We think it has worked pretty well.

ADVANCED X-RAY ASTROPHYSICS FACILITY

Mr. STOKES. Turn to space science and the Advanced X-ray Astrophysics Facility (AXAF), on page RD3-6. We note that you are requesting $260,300,000 for this project in 1994. As the justifications note on page RD3-7, this project responded to financial pressures by being split into two projects. The first, a five-year mission, will be launched in 1998. The second one, a three-year mission, will be launched in 1999. What is the total current estimated cost of both programs exclusive of launch vehicles?

Dr. HUNTRESS. I am Wesley Huntress. The current range for the total cost of development is $1,770 to $1,790.

Mr. STOKES. This mission has been held up as an excellent example of how given the tight budgets we face, we can deal with the budget issue and still keep the mission alive.

Dr. HUNTRESS. Mr. Chairman, I believe what we have done is to level out the cost of the program by taking the peak out of the funding years in order to reduce the annual funding costs for this program. Our intent is to launch these two spacecraft one in 1998 and in 1999, according to the original schedule.

Mr. STOKES. The original cost was $1.6 billion with the flight on the shuttle; correct?

Dr. HUNTRESS. That is correct.

Mr. STOKES. Now, both missions will cost $1.7 billion; correct.

Dr. HUNTRESS. That is correct.

LAUNCH COST

Mr. STOKES. What is the cost for the two ELVs required for launch, a Titan IV and a Delta?

Dr. HUNTRESS. At the present time we are baselined on the Shuttle, with an upper stage, for the AXAF-I mission. For the AXAF-S, which is the second mission, that is baselined on a Delta II. Delta II is approximately $55 million. The cost for the shuttle, if you include marginal costs for each individual flight, is on the order of, I believe, $168 million. It is $48 million for the marginal cost for the Space Shuttle but total costs for the shuttle and upper stage is $168 million.

Mr. STOKES. Our point of concern is, because of the budget crunch, neither NASA nor Congress can meet the funding profile of the original $1.6 billion, so today we are looking at total costs of $2.1 billion, including the launch costs. Does that make sense?

Doesn't that perhaps suggest that there is too much here on the plate?

Mr. ALLISON. What we have done is move costs for AXAF out of the two big funding years, fiscal year 1994 and 1995. We moved the requirements that we previously had on the original mission in 1994.

Mr. STOKES. But the end result in your actions is that it drove up the total costs; isn't that correct?

Mr. ALLISON. Previous to this year, the range for AXAF, Mr. Chairman, for the development, only was $2 to $2.2 billion.

Mr. STOKES. You are not talking about the original costs?

Mr. ALLISON. No, sir, I am talking about the costs in 1993 that caused us to restructure this program.

Mr. STOKES. That was based on the facts that we could not fund the program.

Mr. ALLISON. Right. Mr. Chairman, as of FY 1993, when we made the decision to restructure the program, we were looking at a development program of $2 billion to $2.2 billion.

The development costs have been reduced from $2.2 billion to a range of $1.77–$1.97 billion. And the launch cost, assuming we stay on the shuttle, was $200 million and now it is $216 million. As part of this restructuring, we have reduced the development costs. You are correct, when it started a number of years ago, the development estimate was $1.6 billion.

Mr. STOKES. I guess the point we are trying to make is that we could not fund it at the $1.6, which sort of brought to bear the need to flatten it in the front years. But instead, we are confronted now with the costs of $2.2 billion when we were not able to fund it at $1.6.

Mr. GOLDIN. Yes, and between the points of that initial program estimate and FY 1993, we kept compressing the fiscal funds and stretching it out. We have now restructured the program, and, in the process of restructuring the program, we have held the launch of the first unit and we have reduced the development costs. We have changed the paradigm.

Mr. STOKES. I guess it is a concern of the subcommittee's in the sense that there is too much on the plate, because—with the realization that in the original instance, we could not fund the $1.6, and now we are up to the current rate in terms of the overall budget constraints.

Mr. GOLDIN. What I am saying is, we recognized that when we took a look in FY 1993 at the $2–$2.2 billion, and pulled down the overall development cost of the program. We took specific action in 1993 to bring the overall program costs down. We tried to fix part of the problem that developed from when the program started until 1993 by restructuring the program. Rather than doing what we had been doing in the past, squeezing the fiscal funding and stretching it out, we held the end date, restructured the program, and we pulled out a significant amount of money.

Mr. STOKES. Part of the concern is that when you split the mission on the two ELVs, of course the costs went up as a result of that.

Mr. GOLDIN. Right now we have baseline on the shuttle for the imaging mission, and that is our baseline. We are exploring the possibilities of using the Titan IV/Centaur, which we have not yet committed to, and we are exploring those costs with the Air Force.

When we first started talking to the Air Force about the Titan IV/Centaur, we had very high numbers; and as time has progressed, we are beginning to get lower numbers. But we are not ready to come forward yet and say, this is the right thing to do. The launch costs have gone up $16 million, and relative to the 1993 budget, we have brought the overall costs down $200 million.

REDUCING IMPACT ON NASA BUDGET

Mr. STOKES. As you know, the committee has consistently urged NASA to fly as many of these missions as are technically possible on shuttle or shuttle/TOS in order to reduce the impact on the NASA budget.

Let me give you an example. If we buy Titan IV for this AXAF launch, the full $275 to $300 million cost of the vehicle shows up in the space flight account with an outlay rate of 69 percent. On the other hand, if we fly it on the shuttle, it essentially comes free to the committee; and to a certain extent, it comes free to NASA because we are flying shuttle anyway. Of course, we recognize that if you fly it on the shuttle you have to pay for an upper stage, but the cost of that is still significantly less than purchasing a Titan IV launch vehicle.

In other words, we are saying it is not just a difference in the cost of a Titan IV launch versus a shuttle launch. It is the fact that the shuttle launch essentially comes free; and that is our rationale, and we just would appreciate having your response.

Mr. GOLDIN. Mr. Chairman, the launch isn't free on the shuttle. There is a $40 million marginal cost that we would have to pay, plus we would have to buy an upper stage. That cost will have to be there as compared to going off on a Titan IV Centaur, and that is roughly where this $200 million comes from.

Mr. STOKES. Another way to look at this issue is, if we fly this mission on Titan IV and our allocation requires us to reduce the NASA budget, we have to cut other NASA programs in order to fund the launch vehicle. I am not sure you want us to do that.

Mr. GOLDIN. There are two points that pertain to this issue. Point one is, there is a national launch strategy which says the Administrator must justify any payload that doesn't involve human interaction going on the shuttle. So we are trying to understand the justification for putting the AXAF in the shuttle.

Secondly, there is an issue brought forward in the scientific community that we are trying to evaluate. The scientific community indicated that the productivity of the AXAF spacecraft goes from 65 to 95 percent if you put it on a Titan/Centaur. However, we are very concerned about budget, and we have not yet made a decision about going on the Titan IV and leaving the shuttle; and we are working the issue right now in real time. We would not want to jeopardize the overall mission, and have to take both items into account.

Not only did we reduce the development costs and hold the schedules of the first launch on AXAF, but we were looking at a $3 billion operations and maintenance budget on AXAF, and now we are looking at a budget closer to $300 million. So we have reduced that budget by $2.7 billion, which is part of the bow wave that we are all concerned about.

I am very proud of the team. We have done something very bold that we haven't done before; that is, we have looked at the total life cycle costs of the program including the launch costs. But I also ask you to consider that reducing out-year funding of $2.5 billion, I think, is a major achievement for NASA.

HUBBLE SPACE TELESCOPE OPERATIONS

Mr. STOKES. On page RD3-21 the Hubble Space Telescope Operations activity is carried. You are requesting $222,200,000 for Hubble operations in 1994. What is the total cost of the Hubble repair mission, and do we understand correctly that you are planning to fly two Hubble repair missions, one in December and one next year?

Dr. HUNTRESS. The cost of the Hubble repair mission in December this year is about $251 million in total. That includes the Corrective Optics Space Telescope Axial Replacement (COSTAR), which is to repair the aberration in the mirror; the Wide Field Planetary Camera II with its corrective optics; other flight hardware testing; and software. Of that, about $86 million can be attributed to repairing the optics.

Mr. STOKES. Not the launch cost, though?

Dr. HUNTRESS. That does not include the launch costs.

Mr. STOKES. When are you going to fly?

Dr. HUNTRESS. Early December—I believe December 3rd or 4th.

Mr. STOKES. Will there be a second one next year?

Dr. HUNTRESS. We are examining what our servicing strategy for Hubble ought to be. At this time, we have a fixed schedule, the flight in December of this year and another flight in 1997. This was the original schedule for how we were going to service the telescope. In light of the troubles we have had with some of the subsystems on the Hubble, we are taking a look at the possibility that we might want to adopt a more flexible scheme for doing the Hubble servicing. We are considering a planning process such that, if we decide that we want to do something within a year, we could do that, go back up and fix the telescope.

Mr. STOKES. We are going to ask you——

Mr. GOLDIN. Mr. Chairman, in about a week or two, I am going to receive a final report from a special advisory panel that I had convened to look at the Hubble servicing mission to establish the confidence level and the timeline and to see if it would be necessary to have a backup mission available in case we could not complete all that activity. I expect to have the report in a few weeks, and when we get the results, we will make it available to the Committee.

[The information follows:]

HUBBLE SERVICING MISSION

Attached is the Report of the Task Force on the Hubble Space Telescope Servicing Mission.

REPORT OF THE TASK FORCE ON THE HUBBLE SPACE TELESCOPE SERVICING MISSION

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1. INTRODUCTION

The Task Force was chartered by the Administrator of NASA, Daniel S. Goldin, to review all aspects of the first Hubble Space Telescope (HST) servicing mission scheduled for December 1993. Mr. Goldin, in a letter dated 26 January 1993 to Dr. Joseph F. Shea, Chairman of the Task Force, stressed the "importance, complexity, and visibility of this mission." The review was conducted over a period of five weeks (4 February 1993 through 9 March 1993) and centered on a series of informational briefings conducted at the Goddard Space Flight Center (GSFC), the Johnson Space Center (JSC), Lockheed Missile & Space Company Headquarters, and NASA Headquarters. The members of the Task Force are listed in Appendix 1.

HST is one of the great orbital observatories planned by NASA. Launched 24 April 1990, HST can produce exceptional image detail for bright, high-contrast objects such as nearby star clusters, the cores of galaxies, and solar system planets. The HST has proved to be an extremely valuable scientific resource and has already enabled several major discoveries.

Despite its successes, HST has experienced a series of problems and anomalies. To correct for the problems and restore redundancy, a Space Shuttle crew will conduct the first servicing mission in December 1993. During the course of the review, it became clear to the Task Force that this mission is the most comprehensive and challenging on-orbit servicing mission NASA has ever attempted. It will require more extravehicular activity (EVA) than ever before planned for a single Space Shuttle mission. The mission has three basic goals:

- Correct for spherical aberration of the primary mirror.
- Reduce the observatory's pointing jitter.
- Restore redundancy in key systems.

Many of the servicing tasks are complex and all must be performed in a limited amount of time. During this time, astronauts will be asked to perform the following tasks:

- Install an optics package called the Corrective Optics Space Telescope Axial Replacement (COSTAR).
- Install a replacement for the current Wide Field/Planetary Camera (WF/PC I), called WF/PC II.
- Install two or more sets of gyroscopes and associated electronics.
- Replace the solar arrays.
- Install a computer co-processor.
- Install a repair kit for the Goddard High Resolution Spectrometer (GHRS).
- Replace the Magnetic Sensing System #1 (MSS-1)

In evaluating the effort required and the risks, it must be remembered that HST was designed for servicing and is therefore more compatible with crew servicing requirements than any other satellite produced to date.

2. EVOLUTION OF HST SERVICING PLANS

HST was designed and built for periodic on-orbit servicing. The current plan calls for servicing missions roughly every three years throughout the course of HST's 15 year life. Critical components are located in 50 unique types of orbital replacement units (ORUs). The ORUs were designed for easy access, removal, and replacement. In addition, 225 feet of crew translation hand holds and 31 portable foot restraint receptacles were provided on the surface of HST. These were placed to allow a servicing crew to move across the surface of the satellite, position themselves at any servicing location, and then reach the ORUs or related hardware.

At the start of HST development in 1977, all HST components except wiring, structure, thermal control surfaces and heaters, and the Optical Telescope Assembly optics were to be serviceable on-orbit. Early plans also included periodic return to Earth via the Shuttle for full refurbishment.

In 1980, however, as part of a cost reduction program, the requirements for on-orbit serviceability was eliminated for a number of components, such as the multiple access transponder, the data management unit, the data interface units, the power distribution units, and the solar arrays. Four years later, the decision was made to eliminate ground return for periodic refurbishment as an option. This decision was based on unanswered technical concerns regarding the impact of ground return and relaunch, many of which still exist today. As an example, HST has strict contamination control requirements which are necessary for successful ultraviolet performance and which would be difficult to maintain during ground return and servicing. In addition, as Shuttle-coupled loads increased, the predicted mechanical stresses on many HST primary structural elements increased to the point that fracture control restrictions limited the HST to a single launch. Another major consideration was the significant cost of ground return. Estimates indicated that manpower levels during refurbishment would approach those experienced during HST's initial development far exceeding the on-orbit servicing costs.

Following the decision to eliminate HST ground return, an effort was initiated to significantly upgrade HST on-orbit serviceability. By that time, budget constraints had left only 20 unique ORUs with designs allowing complete EVA serviceability. EVA-compatible aids, such as captive fasteners, wing-tab connectors, tether loops, alignment decals, and connector maps, were added to the design of an additional 24 ORUs. This set of redesigned ORUs is now referred to as Block II, while the original set of 20 ORUs is referred to as Block I. A third category, Block III, is composed of six ORU spares which were minimally enhanced to support EVA serviceability. These three blocks of ORUs have decreasing levels of EVA compatibility, but collectively enhance the basic serviceability of the HST design. Table 2.1 below,

provided by the HST Flight Systems and Servicing Project lists the candidates for repair or replacement during the first servicing mission and their block designation.

TABLE 2.1 PAYLOAD COMPLEMENT AND PRIORITIES

Item	Priority Class	Priority Sequence	Block
Solar Arrays (SA)	1	1	I
Wide Field/Planetary Camera II (WF/PC II)	1	2	I
Corrective Optics Space Telescope Axial Replacement (COSTAR)	1	2	I
Rate Sensor Unit-2 (RSU-2)	1	3	I
Coprocessor	1	4	I
RSU-3	1	5	I
Electronic Control Unit-3 (ECU-3)	1	6	I
Goddard High Resolution Spectrograph (GHRS) Repair Kit	2	7	I
Magnetic Sensing System-1 (MSS-1)	2	8	III
ECU-1	2	9	I
Fuse Plug	2	9	I
RSU-1	2	9	I
MSS-2 Blanket	3	10	N/A

Although design compromises were made which reduced the EVA serviceability of certain ORUs, the Task Force believes that in-orbit serviceability is adequate and lower risk than ground servicing. Ground return should be considered only in the event of equipment failures which threaten HST and cannot be remedied by on-orbit servicing.

3. HST SYSTEM RELIABILITY

HST system and subsystem reliability is one of the key issues affecting the servicing missions. To effectively plan for the first and future refurbishments, the source of the failures and the failure rates must be understood and quantified. To understand the consequences of management decisions, the risks should be quantified and assessed. Unfortunately, the original reliability specification for this mission was very loosely stated:

> "Orbital Replacement units either individually or by design redundancy shall have a minimum of 2.5 years on-orbit operative life."

We believe that failure rate tracking, and overall assessments of risk have not been adequately performed. Although we were shown some recent updates, they did not include confidence levels and cumulative probabilities. Also, the cause of the some of the failures is still unknown, raising questions about the viability of the replacements.

The HST program office at GSFC established a position of not testing the telescope redundancy (side-A versus side-B) on-orbit, unless the benefit of the testing outweighs the risk of switchover-induced failures. There is always a non-quantifiable risk that something will go wrong when switching: people, procedures, software, hardware, etc. Thus, the HST program lives without complete knowledge of the health of various HST subsystems and individual units.

Informed management decisions cannot be made without adequate reliability assessments. For example:

- When should future servicing missions be planned (which should be based on updated ORU failure rates)? What are the confidence levels associated with those rates?
- What is the confidence that the replacement units will fix the failure problem?
- What components should be upgraded for use in later retrofit missions?
- Is the current failure rate "normal"? If not, what should be inferred?
- What are valid failure rates for components in space when they are not being used?
- What mission risks (e.g. risks to science data-taking) are a consequence of these failure rates?
- Is the decision to not turn on the B side of certain subsystems based on facts or philosophy? Note that the status of these subsystems is not known, nor is it planned to assess them.

Regarding individual component and subsystem failure rates, a detailed, on-going assessment should be made, based on all information available. This should include an assessment of the following effects which could increase or decrease failure rates:

- The impact of extensive (up to 9000 hours) ground testing.
- The impact of "storage-on-orbit".
- The impact of temperature fluctuations.
- The implications of knowing that certain subsystems have already survived launch, and hence will not see further shock or vibration.

Using appropriate statistical inference techniques, confidence levels should be established and used by Hubble Program management in both planning and operational decisions. The risk implications should be included in top level management decisions.

Regarding the specific data which were shown, we believe the rate gyroscopes and associated electronics have shown unacceptable failure rates and jeopardize science mission quality although we see little danger to the safety of the spacecraft. The originally predicted Mean Time Between Failure (MTBF) rates for the gyros were predicted to be 14.5 years; the updated HST failure rate, based on actual performance, is now estimated to be 3.8 years. Except for the computer memory, which is being augmented with more reliable components, the gyroscope units are the least reliable element on HST. We therefore recommend that all gyroscope units, including the mechanical gyroscope and all associated electronics, should be replaced as soon as possible, using gyroscope units with known improved reliability.

4. REQUIREMENTS AND PLANS FOR THE FIRST SERVICING MISSION

The first HST servicing mission is designed to restore the full scientific capability to the spacecraft and to ensure the telescope systems continue to function and produce quality observations. The current priority of the various repairs has been divided into two categories - primary and secondary, as shown in the following table (Table 4.1) provided by the HST Project, Associate Director's Office. The primary repairs are those which are necessary for the mission to be regarded as successful. The secondary objectives will be met as time and resources allow. The actual mission plan does not directly follow this sequence because of Shuttle and HST limitations.

Table 4.1 HST First Servicing Mission Payload Overview

Failure/Anomaly	Cause	Response	Comments	Category
Spherical Aberration	Primary mission ground to wrong prescription	WF/PC-III and COSTAR with corrective optics	Correction necessary to meet Level I requirements	Primary
Solar Array Jitter	Thermal deformations of array structure	Solar Array II with thermal shielding and improved mechanical design	Solar Array experiencing deformations outside of design envelope causing unacceptable attitude transient motion	Primary
Gyroscope Failures	Gyro 4 and 6: generic problem with Bendix pulse rebalance loop hybrid circuits	Retrofit of spare rate sensing units with Teledyne hybrids	3 of 6 gyros necessary to conduct science mission	Primary
		Changeout of RSU 2 and 3	5 gyros following first servicing mission increase failure tolerance	Primary
	Gyro 6 motor spindown: random failure of spin motor power phase-open circuit most likely originating in electronics	Changeout of ECU-3	Change out of RSU-3 already planned	Primary
	Gyro 1 shutdown: short circuit causing fuse to open, most likely originating in ECU	Changeout of RSU-1, ECU-1 and fuse plug	Investigation not yet complete	Secondary
DF-224 Memory Unit Failures	Memory Unit 3: open of plated through hole on 7 layer board	Augment memory with coprocessor/shared memory unit	Problem believed to be generic board problem	Primary
			Stress cycling of spare boards proved tolerance	
	Memory Unit 4: failure of read/write enable circuitry	Coprocessor/shared memory augmentation		N/A
GHRS Low Voltage Power Supply Failure	Intermittent open of lug solder joint	Science data cross-strapping via relay box	Use of built in redundancy requires switch over of entire HST data management	Secondary
Magnetometer Anomalies	Intermittent open on signal path of V2	Replace Magnet Sensing System #1	Attitude/thermally induced	Secondary
			Not generic problem	
Gyro Fuse Derating	Appears to be improper fusing for gyro power circuits	Under review	3.0 Amp fuse must carry 2.0-2.8 Amps for 27 sec.	N/A

The requirements and order of priority are constamtly changing, given the extended mission preparation period and the changing status of the observatory. This instability impacts the mission preparation and mission operations training. It also places an additional load on astronaut and support team training. An additional concern is the escalating nature of the mission. Starting with a few objectives, the mission has grown to an unprecedented number of EVAs. While the rate of failures is not unusual for a spacecraft of this complexity, the current servicing plans include replacing some very large and sensitive ORUs.

The HST Project, the integration contractors, and the mission operations personnel have done a good job of pre-mission design and preparation for the periodic servicing of HST given the changing servicing philosophy throughout the development of the program. The development of EVA tasks, tools, and support hardware has progressed over the years of designing and building the HST. The prelaunch verification of the tools, including fit-checks to the flight unit and manned thermal vacuum testing and the planning for verification prior to the first servicing mission, has been methodical and adequate.

Although a great deal of planning and care has clearly gone into contamination control, the Task Force is concerned about the possibility for contamination of HST optics and other sensitive systems during the EVA. Possible sources of contamination include the EVA suits and tools. We recommend that orbital testing be conducted prior to the servicing mission to assess potential contamination using such techniques as witness plates.

As the launch nears, there is the potential for new failures which could change the relative priority of repairs and impact mission training and other preflight planning. New failures also have the potential to overload this single mission. This concern is heightened by the unknown causes of some of the existing failures. This mission already challenges the capability of the Shuttle and crew. In-depth planning for credible, but currently unknown, failures is required to prepare for this flight.

Past EVA history suggests that complex EVAs often encounter unexpected events which can significantly alter plans and time lines. This experience, coupled with the complexity of this servicing mission strongly suggest the need to plan for a second servicing mission. A second mission may also be required to compensate for a greater than anticipated failure rate following the initial mission. The schedule for the next planned mission may have to be accelerated or an additional mission may need to be inserted to maintain the telescope's health and enable the continuing science mission.

5. MISSION MANAGEMENT AND TRAINING

The HST servicing mission is the most complex Shuttle mission ever attempted. The accompanying mission planning and training also are quite complex. Mission preparation activities are managed by the Space Shuttle Program within the Office of Space Flight. Mission planning and training primarily are the responsibility of the Johnson Space Center with support from the Marshall Space Flight Center. The actual mission planning and training are accomplished by a large team composed of members from these two Centers and from the HST Program Office at the Goddard Space Flight Center. The Task Force commends the people involved in this mission for the tremendous amount of work they have already done in preparation for this mission. We recognize that more advanced planning and effort has gone into preparing for this mission than for almost any previous Shuttle mission.

The Task Force, however, found the interfaces between the organizations involved to be numerous and confusing. No single individual was charged with addressing all of the issues which might arise during mission preparation and who would be totally accountable for mission success. This problems appears to be under work, however.

In response to criticism by various review teams, a mission director has been assigned by NASA Headquarters. Effective cooperation between the Centers involved in this mission is absolutely essential to its success. A more complete distribution of these data could result in a better overall examination of the options. There should be no reluctance to hear proposals based on shared information; it is an accepted fact that, in the end, a decision must be made and that such a decision cannot be shared.

A chief concern of the Task Force is the amount of work that must be completed during a single Space Shuttle mission. The mission preparation for the first servicing mission follows the standard mission planning and training format for Shuttle missions and thus places much of the work in the last year prior to launch. The training and operations products are currently on schedule. However, the number of servicing tasks, the telescope's complexity, and the large size and numbers of ORUs to be repaired or replaced make the first servicing mission an EVA job that is unprecedented, and thus strongly indicate that pre-mission planning should have begun earlier than in past EVA missions. Given the mission's complexity, we also recommend that back-up crew members be assigned to train for the critical mission tasks.

Current EVA time line development activities indicate that four or possibly five days of EVA may be necessary to complete the objectives of this first servicing mission. In general, we find the current EVA time lines to have insufficient slack. The EVA time

required has increased over 25 percent during February alone. In addition, some of the hardware appears to be behind schedule (e.g., COSTAR). These factors raise concerns about the viability of the overall schedule and further support the need for accelerated mission operations preparation.

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6. PLANNING FOR ADDITIONAL SERVICING MISSIONS

As mentioned previously, periodic servicing of HST has always been an important element in its 15-year life cycle. In determining servicing requirements, the planners were guided by the following basic objectives:

- Upgrading of HST instruments to enhance science capability
- Reboosting of HST to an orbit where it could survive the orbital drag created by a worst-case solar cycle
- Replacement of ORUs based on predicted degradation
- Replacement of failed ORUs

Once ground return was eliminated as an option in the mid-1980s, planning focused solely on an on-orbit servicing approach. In order to predict hardware failures, an extensive performance trend program was developed. The data it produced was used in setting servicing mission payload complements and time lines. The limitations on mission planning were as follows:

- Availability of Shuttle flights
- Capacity of the Shuttle payload bay
- Limits in EVA duration
- Availability of spare ORUs

Given these considerations, a servicing plan was developed early in the HST program. Table 6.1 provides an overview of that plan.

Table 6.1 HST Lifecycle Program - Prelaunch Servicing Scenario

CATEGORY	1993	1996	1999	2002	2005
Instruments	Ensure WF/PC	NICMOS STIS	ARC	To be determined	De-orbit
Solar Cycle	Reboost if Shuttle capability allows	Reboost	Reboost critical	Reboost if Shuttle capability allows	
Planned ORU Replacement		Solar Arrays Batteries		Solar Arrays Batteries	
Candidate ORU Replacement include	Gyros Tape Recorders SI C&DH FGS/FGE Reaction Wheels	Gyros Tape Recorders DF224/DMS FSG/FGE Reaction Wheels Transponder	Gyros Tape Recorders SI C&DH Reaction Wheels	Gyros Tape Recorders DF224/DMS FGS/FGE Reaction Wheels	

Since being placed in service, HST has encountered a series of unexpected problems and anomalies. Of these, the major ones (i.e., spherical aberration of the primary

mirror, jitter caused by Solar Arrays, and abnormally high gyro failure rate) were obviously not factored into the original planning for servicing missions.

The need to correct for the spherical aberration forced changes to WF/PC II and led to the creation of COSTAR. In addition, it pushed the schedule for the first servicing mission from June 1993 to December 1993 and the second mission from mid-1996 to early 1997. The scope of the Space Telescope Imaging Spectograph (STIS) and Near Infrared Camera and Multi-Object Spectograph (NICMOS) instruments was also reduced as a result. The requirement to replace the Solar Arrays on the first servicing mission because of the jitter they are causing will likely accelerate the installation of the second set, but no additional arrays should be needed over the lifecycle of the HST. These and the other new requirements led to a restructuring of the servicing mission plan which is outlined in Table 6.2 below.

Table 6.2 HST Lifecycle Program - Updated Servicing Scenario

CATEGORY	1993	1997	1999	2002	2005
Instruments	*WF/PC II* *COSTAR*	*NICMOS* *STIS*	ARC	To be determined	De-orbit
Solar Cycle	Reboost if capacity	Reboost	Reboost critical	Reboost if capacity	
Planned ORU Replacement	*Solar Arrays* *Batteries* *Gyros*			Solar Arrays Batteries	
Candidate ORU Replacement includes:	*Coprocessor* *GHRS mod* *Magnetometers*	Gyros Tape Recorders DF224/DMS FSG/FGE Reaction Wheels Transponder	Gyros Tape Recorders SI C&DH Reaction Wheels	Gyros Tape Recorders DF224/DMS FGS/FGE Reaction Wheels	

Note: Revisions to prelaunch scenario highlighted with italics

Of particular concern to the Task Force was the planned interval of 38 months between the first servicing mission in December 1993 and the second in January 1997. Current planning sees three options in the event that the distribution of failures is worse than predicted:

- Develop on-orbit workarounds
- Reprioritize replacement cargo on the second servicing mission, thus deferring lower priority fixes or instrument upgrades; and
- Fly the second servicing mission earlier than planned or schedule additional servicing missions

The Task Force feels that planning for the next servicing mission should also take into account the possibility that the first mission will not accomplish all of its objectives. Given the complexity of the first mission, such an outcome is not seen as remote. Under these circumstances, the Task Force strongly recommends that planning begin immediately for a follow-on servicing mission to be undertaken no later than six to twelve months after the first mission. The purpose of this mission would be to complete any unfinished tasks and to correct new problems and anomalies which may develop.

7. CONCLUSIONS AND RECOMMENDATIONS

Conclusions

1. The Hubble Space Telescope (HST) system is well designed to meet its continuing mission objectives. This design includes adequate redundancy within the spacecraft, a satisfactorily structured repair and refurbishment plan, and long-term science upgrades. We judge the first servicing mission to be feasible.

2. A major amount of in-depth effort has been put into this mission and significant progress has been made. The coordination and cooperation among the Office of Space Flight, the Office of Planetary Science and Astrophysics, the Goddard Space Flight Center, the Johnson Space Center, and the Marshall Space Flight Center is especially noteworthy.

3. The mission is very complex and contains the following risks:
   - The EVA time line is very tight and has grown about 25% during February.
   - The EVA planning, training and scheduling is late, considering the complexity of the time line.
   - The management structure has been diffuse. Recent changes are encouraging, but require further senior management attention.

4. The schedule of all activities between now and launch has inadequate margin. The principal replacement units are late and major testing still remains.

5. The component failure rate is worrisome:
   - The impact of failure rate on risk has not yet been adequately assessed.
   - Some failures are not yet fully understood.
   - No redundancy remains in some key areas (e.g., gyro systems).
   - The recent fine guidance sensor anomaly is a matter of concern.
   - Additional failures before the servicing mission could impact the planning schedule.

6. The current flight plan is designed solely for Orbiter 105. This limits flexibility as other Orbiters are less capable.

7. The current plan does not include verifying the operability of all redundant HST subsystems.

8. A major effort has been applied to controlling contamination. Orbital testing is needed to assess potential contamination from EVA suits and tools.

Recommendations

1. Focused management is essential to this mission. The recent management changes are positive and must be sustained. Close senior management attention, including formal reviews, must be continued to ensure that the new organization remains effective.

2. Development of the EVA time line and choreography, including contingencies, is necessary in order to properly plan the entire mission and should be accelerated. As soon as the time line is available, it should be reviewed by senior management.

3. Training for the mission must include joint integrated end-to-end simulations of the EVA portions.

4. HST recovery and return to Earth should not be considered unless repair is not achievable on-orbit. The overall risk and cost of the return and refurbish option is not otherwise justifiable.

5. Assure that the upgrades to the Neutral Buoyancy Simulator (e.g., Nitrox, video and RMS) are completed in time to support the joint simulations.

6. Designate and train a backup EVA crew member now.

7. Ensure that the current plan to exercise on-orbit HST repair procedures on an earlier Shuttle flight is implemented. This should include the use of witness plates to assess potential contamination issues.

8. Reassess priorities of the repair sequence. Give higher priority to replacing all gyroscope units.

9. Plan now for an early contingency mission to cover potentially incomplete tasks from the first servicing mission or additional failures on the spacecraft.

10. Conduct a quantitative assessment to determine the risk of verifying the status of all subsystems (both A- and B-sides) before the first servicing mission.

11. Conduct an integrated assessment of contamination control procedures and plans for the HST servicing missions.

APPENDIX A

LETTER FROM THE ADMINISTRATOR OF NASA TO DR. JOSEPH F. SHEA DATED 26 JANUARY 1993

NASA
National Aeronautics and
Space Administration
Washington, D C
20546
Office of the Administrator

January 26, 1993

Dr. Joseph F. Shea
Professor of Aeronautics and Astronautics
Massachusetts Institute of Technology
Room 33-213
77 Massachusetts Avenue
Cambridge, MA 02139

Dear Dr. Shea:

The Hubble Space Telescope (HST) has already proven itself an exceptional astronomical facility providing significant scientific results and furthering our understanding of the universe in which we live. Hubble's scientific accomplishments to date have been achieved through outstanding teamwork overcoming numerous operations and scientific problems, the most significant being the spherical aberration of the primary mirror. The HST was originally conceived to have a fifteen-year lifetime, achieved through planned Shuttle servicing, consisting of upgrading science instruments, and repairing or replacing failed components. The first planned Hubble servicing mission will correct the spherical aberration and other problems which have arisen since launch, thereby providing even greater scientific return in the future.

The servicing mission is scheduled to be flown in December of this year, in approximately eleven months. New problems, however, continue to arise on Hubble and the requirements for the servicing mission are becoming increasingly ambitious and complex. Enclosure 1 shows that seven systems/components are priority one items. This implies that mission success requires their successful replacement or repair. An additional six items are desired to be replaced/repaired as time allows, listed as priority two. The mission is also scheduled for a night launch and will involve flying and operating two large IMAX cameras, one in the payload bay and one in the cabin. Clearly, this is a demanding mission.

Given the importance, complexity, and visibility of this mission, as well as the visibility of the problem that resulted in the primary mirror flaw, a number of teams have reviewed various aspects of the mission. These reviews have, for the most part, been accomplished by NASA, focusing on various aspects of the mission. The Hubble Space Telescope is truly a national asset that has already provided tremendous results and

offers the potential for even greater discoveries for years to come. It is essential that this first servicing mission be planned and implemented to ensure the highest probability of success. I have just initiated a process for holding mission reviews of certain significant flights by outside experts on a regular basis. I am considering identifying the Hubble servicing mission as one of these significant flights for review.

It appears to me that you may, as Acting Chairperson of the NASA Advisory Council, be the appropriate person to head the Hubble review. In order to make the final determination on the wisdom and make-up of such a review, I invite you, and any experts you wish to bring with you, to an informational briefing on the Hubble repair mission on February 4, 1993. After that meeting, we will decide on the appropriate course of action. This will include commencing any actions necessary to ensure all meetings subject to the Federal Advisory Committee Act are conducted in the appropriate manner.

Considering the mission is scheduled in just eleven months, the decision to begin the review is obviously time critical, since any changes to be made to the flight to ensure its success must be made at the earliest possible date. To promote rapid but informed decisionmaking, at the February 4 meeting your group will be provided the results of past reviews along with input from all organizations that are involved in the servicing flight. I would be pleased to meet with you to discuss the upcoming meeting. Please feel free to contact me if you have any questions.

Sincerely,

Daniel S. Goldin
Administrator

Enclosure

cc:
AD/Mr. Holloway
AH/Dr. Fisk
G/Mr. Frankle
H/Mr. Lee
I/Mrs. Finarelli
M/Gen. Pearson
S/Dr. Huntress
SZ/Dr. Newton
GSFC/100/Dr. Klineberg
JSC/AA/Mr. Cohen
JPL/180-904/Dr. Stone
KSC/CD/Mr. Crippen
MSFC/DA01/Mr. Lee

ENCLOSURE 1

ITEM	Priority Class
Solar Arrays	1
Wide-Field Planetary Camera II (WF/PC II)	1
Corrective Optics Space Telescope Axial Replacement (COSTAR)	1
Replaceable Serviceable Unit (RSU 2)	1
Co-processor	1
Replaceable Serviceable Unit 3 (RSU 3)	1
Electronic Control Unit 3 (ECU 3)	1
Goddard High Resolution Spectrograph Repair Kit (GHRS)	2
Magnetic Sensing System 1 (MSS 1)	2
Electronic Control Unit (ECU 1)	2
Fuse Plug	2
Replaceable Serviceable Unit 1 (RSU 1)	2
Magnetic Sensing System 2 Blanket (MSS 2)	2

APPENDIX B

TASK FORCE ON
THE HUBBLE SPACE TELESCOPE SERVICING MISSION
Membership List

Dr. Joseph F. Shea, Committee Chairman
Adjunct Professor of Aeronautics and
Astronautics
Massachusetts Institute of Technology

Dr. Eugene E. Covert
Professor of Aeronautics and
Astronautics
Massachusetts Institute of Technology

Dr. Maxime A. Faget
Chairman of the Board
Space Industries, Inc.

Dr. Richard L. Garwin
IBM Fellow
IBM T. J. Watson Research Center

Dr. George J. Gleghorn

Maj. Gen. Ralph H. Jacobson (Ret.)
President and CEO
The Charles Stark Draper Laboratories

Dr. Herbert Kottler
Head, Aerospace Division
Massachusetts Institute of Technology
Lincoln Laboratories

Mr. Edmund Nowinski

Prof. Bradford Parkinson
Gravity Probe B
Hansen Experimental Physics Laboratories
Stanford University

Mr. Charles Roth

Mr. Harris Schurmeier

Lt. Gen. Thomas P. Stafford, USAF (Ret.)
Stafford, Burke and Hecker, Inc

APPENDIX C

ACRONYM LIST

ARC	Advanced Radial Camera
COSTAR	Corrective Optics Space Telescope Axial Replacement
DF-224	Support Systems Module Onboard Rockwell Computer
DMS	Data Management System
ECU	Electronic Control Unit
EVA	Extra Vehicular Activity
FGE	Fine Guidance Electronics
FGS	Fine Guidance Systems
GHRS	Goddard High Resolution Spectrograph
GSFC	Goddard Space Flight Center
HST	Hubble Space Telescope
JSC	Johnson Space Center
MSFC	Marshall Space Flight Center
MSS	Magnetic Sensing System
MTBF	Mean Time Between Failure
NASA	National Aeronautics and Space Administration
NBS	Neutral Bouyancy Simulator
NICMOS	Near Infrared Camera and Multi-Object Spectograph
ORU	Orbital Replacement Unit
RSU	Rate Sensor Unit
SA	Solar Array
SI C&DH	Scientific Instrument Control and Data Handling
STIS	Space Telescope Imaging Spectograph
WF/PC	Wide Field/Planetary Camera
WF/PC II	Wide Field/Planetary Camera II

Mr. STOKES. For the record, provide us with total cost of Hubble over its 15-year life, the total life cycle costs. Also, what was the cost of the development, the cost of operations over that 15-year period, the cost of repair missions, including shuttle launches, and the total bill in all respects?

[The information follows:]

Hubble Total Cost

The total costs for the 15-year HST mission are estimated at 6.8-7.2 billion real-year (inflated) dollars The table below shows the elements of this estimate, including actuals through FY 1993 and range estimates for FY 1994-2005, rounded to the nearest $100 million. Inflation is assumed at about 4.5 percent. The estimates for shuttle costs assume six flights, with costs of $40.1 million FY 1994 dollars per marginal flight. The range estimates for FY 1994-2005 reflect current point estimates, plus-or-minus 5 percent.

RY $B	Thru FY 93	FY 94-05	Total
Development	1.5		1.5
Operations/Servicing	1.3	2.9-3.2	4.2-4.5
Data Analysis	.1	.6-.7	.7-.8
Tracking Support	.1		.1
Shuttle	.1	.2	.3
TOTAL	3.1	3.7-4.1	6.8-7.2

It should be noted that the Office of Space Science is currently assessing its total MO&DA budget requirements; the outcome of this assessment could affect the projected ranges.

The HST servicing strategy is to maximize the science return from the spacecraft using four shuttle servicing missions at about three-year intervals. Having established an observatory in space, each servicing mission provides new instrumentation that is equivalent to a new small mission, utilizing an infrastructure which is already in place. Although the repair of unanticipated failures is part of the servicing strategy, the installation of advanced technology instruments provides the potential for new scientific discoveries in a way that earlier missions could not.

Allocating cost to the four planning servicing missions is difficult. Non-hardware cost are not easily split into operations versus servicing; some project personnel may perform tasks to support operations as well as one or more servicing missions on the same day. An approximation (including hardware development and shuttle launch costs in millions of real year dollars) is as follows:

Mission	Hardware	Other*	Shuttle	Total
1993	160	90	38	288
1997	200	100	46	346
1999	100	110	50	260
2002	100	120	57	277

*Non-hardware items such as mission support, ground systems, software, test and integration costs.

ADVANCED X-RAY ASTROPHYSICS FACILITY

Mr. STOKES. Incidentally, what do you anticipate the annual operating costs of AXAF will be?

Dr. HUNTRESS. Prior to the restructure this year, the annual operating costs for AXAF were projected to be $175 million. After the restructuring, they are projected to be on the order of $60 million.

WOODS HOLE SCIENCE STRATEGIC PLAN

Mr. STOKES. Mr. Mollohan.

Mr. MOLLOHAN. Thank you, Mr. Chairman.

What is the status of the science strategic plan that was developed at Woods Hole in 1991?

Dr. HUNTRESS. Mr. Mollohan, as you are aware, in 1991 we did do a strategic planning exercise with the science community to develop a strategic plan for the space sciences, and that particular plan assumed 7 percent real growth in the Agency, which is of course quite different from the current budget situation.

I think that what we are going to do is to relook at the strategic plan. But what is important to note is that the strategic planning exercise in space sciences is extremely important; we will be getting the community's input and determining what our plan ought to be in taking NASA forward in the space sciences.

Mr. GOLDIN. When we restructured the science activity of NASA, I had asked the NASA Advisory Council to take a look at how we might assure ourselves that we have the proper advisory structure and continuity for the strategic planning process, which we believe is critically important. That panel is supposed to report out in early summer with a recommendation on how we could provide that integrated overall strategic planning now that we have three different science activities going on.

The other thing is that we are now looking at a budget averaged over a five-year period that is a little less than inflation. I believe it will be essential to reconvene and relook at our strategic planning process so it comes in line with the budgets that we have. However, until that point in time, we are giving major weighting to the priority setup. As part of our technology package proposal, a number of the programs that we had recommended are included as potential new start activities. So, we are trying to stick with the highest priorities at the present time.

Mr. MOLLOHAN. But they are an investment part of the package?

Mr. GOLDIN. Yes, sir.

Mr. MOLLOHAN. I don't know exactly what I have heard. I have heard, no, we are not sticking with the Woods Hole strategic plan and, yes, we are sticking with the Woods Hole strategic plan.

Mr. HUNTRESS. Yes, we are sticking to the Woods Hole strategic plan.

Mr. MOLLOHAN. With the reduction in funding, how are you doing that?

Dr. HUNTRESS. I broke the program up into several program elements—small, low-cost flight programs, and another queue of medium- and large-cost flight programs. I don't think that any of our disciplines are interested in changing the missions they would like to do. But I think that we may have to readjust the queue and

adopt a new philosophy as to how we do that queue, because the external budget environment has changed.

Mr. MOLLOHAN. With regard to priorities, I hear you do intend to follow the priorities of the strategic plan developed at Woods Hole?

Dr. HUNTRESS. That is true.

Mr. MOLLOHAN. And you have established a working group or a commission—I don't remember what you called it—to assess how you continue to coordinate the efforts now that you have reorganized into three entities; is that correct?

Mr. GOLDIN. Yes. The NASA Advisory Council has been tasked to take a look at how we can provide continuity so that we speak with an integrated voice for the science community.

Mr. MOLLOHAN. Would you care to comment on what could be accomplished prior to their conclusions?

Mr. GOLDIN. We are holding in place a panel looking at an overall NASA program in science until we come up with a plan that would be better.

Mr. MOLLOHAN. Thank you, Mr. Administrator.

Mr. STOKES. Mr. Chapman.

Mr. CHAPMAN. Mr. Chairman, let me wait for a minute.

MARS MISSION

Mr. STOKES. We will come back to you in a little bit.

On page RD4-7 under the planetary programs the Mars 1994 mission is detailed. This mission was designed as a joint effort with the Russians and was originally intended to fly two instruments aboard a third Russian Mars lander. However, the Russians subsequently decided to eliminate the third mission.

Is it correct that the one U.S. instrument will now be flown on each of the remaining two Russian landers?

Dr. HUNTRESS. Yes, Mr. Chairman, that is true.

Mr. STOKES. Is the $7 million shown in 1993 and 1994 the total cost of this mission?

Dr. HUNTRESS. Yes, that is the total cost of the mission and the two instruments.

GALILEO OPERATIONS

Mr. STOKES. On page RD4-12, the request for missions operations data analysis, which totals $160,700,000 is detailed. The amount for Galileo is $57,600,000 600.

What is the total additional cost for the Galileo operations budget resulting from a failure to deploy the high-gain antenna? In other words, what do you anticipate it will cost to make the changes necessary to maximize data return from a low-gain antenna?

Dr. HUNTRESS. It is approximately $50 million over the course of the mission.

Mr. STOKES. Are there sufficient funds within the 1994 request to accommodate the planetary operations budget, including the Galileo problem?

Dr. HUNTRESS. At the moment, we are looking at the total Mission Operations and Data Analysis budget across all of the Office of Space Science to look at how we restructure our program to meet

the fact that we are not growing in this area as fast as we had originally planned.

If you look at the budget across OSS, you will find that it is fairly levelfunded in the interest of trying to keep operating costs low and make our contribution to a deficit reduction. At the moment, we are looking at how we are going to achieve this across-the-board in OSS. In the Office of Space Science, and will be looking at Galileo at the same time.

Mr. STOKES. If it is necessary to make a major reduction in NASA, and the committee applied some kind of a general reduction to the space science budget, would any of that reduction be taken from the $160 million?

Dr. HUNTRESS. We would have to look across the board whether it would apply to Missions Operations over the R&D program.

TOWARD OTHER PLANETARY SYSTEMS

Mr. STOKES. Page RD4-15 under planetary research and analysis, the Toward Other Planetary Systems, TOPS, is detailed. The request is for $12,300,000. This, of course, is the new name for the former program known as Search for Extraterrrestrial Intelligence program.

What is the total SETI/TOPS program from its inception some six or seven years ago to completion, total cost?

Dr. HUNTRESS. We will have to get that for you, Mr. Stokes.

[The information follows:]

SEARCH FOR EXTRATERRESTRIAL INTELLIGENCE/TOWARD OTHER PLANETARY SYSTEMS

The total cost for the Search for Extraterrestrial Intelligence/Towards Other Planetary Systems program from FY 1989 through completion is in the range of $125-135 million.

Mr. STOKES. What are the program's expectations in terms of percentage of likely reception of an extraterrestrial signal?

Dr. HUNTRESS. That is a very difficult number to calculate.

Mr. STOKES. We were waiting to get that one.

Dr. HUNTRESS. I wish I could give you a precise number. I think we all recognize that the probability of finding a civilization might be small, but if we were ever to find one, it would be a monumental discovery. It is a matter of trading off the low probability versus the result that one might get from it.

Mr. STOKES. Mr. Chapman.

SPACE STATION REDESIGN

Mr. CHAPMAN. Mr. Chairman, thank you. I apologize for my tardy entry. We have been having a nuclear defense facilities hearing next door in my other subcommittee.

I want to welcome the witnesses to the process.

I would like to return to the general area and be kind enough not to let me repeat anything or have you repeat something that is already part of the record, which would be redundant or repetitive. I understand there has been some general discussion and concern on the redesign effort of the station. A number of those concerns, you and I have discussed as that effort is ongoing.

Those of us that have been strong supporters of the space station project have worked hard to defend Freedom as the primary vehicle for a re-designed space station. Let me share with you my concerns about-not so much the technical or engineering problems but of the political problems we may have in attempting to do what the redesign team and the administration want to do.

I know your desire is to keep a vital space station alive and doing science. That is a goal we share. My concern is whether or not a major departure from a mature design on as short a fuse as we are currently working with, putting engineering and fiscal ramifications aside, may create a political dilemma. Generating a confidence in the Congress in a redesigned station in literally a period of 90 or 100 days and redoing what has taken us many years to do with the mature design of Space Station Freedom is a concern that has been expressed by Members of both sides of the aisle. This concern is shared by those who have been strong supporters of the current design as well as those that are very open-minded about a redesign.

My question, Mr. Goldin, is if the current design is not selected what is NASA's plan to convince a skeptical Congress that you can do in 90 to 120 days what has taken eight years to do with Space Station Freedom?

Mr. GOLDIN. Let me take the first question and that is to say I want to clarify the role that NASA has in this process. We have been asked to look at three designs, which we are going to do. We are coming up with three configurations—a modular configuration; the Space Station Freedom configuration, scaled back perhaps more in management than anything else; and a new design. We are going to provide cost inputs on those three, and we are going to make sure that the right cost estimates exist for what it would take to get the threshold level of full international participation and permanent human presence. We are not going to take these numbers and put them in a corner and drive them towards one point.

I hope everyone can look to NASA as the honest broker to present data, so decisions can be made. The Blue Ribbon Panel will check and validate the cost estimates. There are a number of members on the panel that will do a cost assessment of what we have, and they have no connection to NASA. The White House will make the decision.

No matter what happens in terms of what configuration is selected, I believe that the existing Space Station Freedom design and approach is going to be a much sounder approach as a redesigned activity because of the management concepts we are looking at, and because of the identification of requirements that don't pertain as much to the science as to the internal workings of the station. I believe we will have a better baseline design.

I cannot speculate on what the costs are going to come out to be for the other two concepts. I wanted to make sure that you understood that there will be a solid database for all three concepts, and we will not just present one little aspect of it.

Mr. CHAPMAN. I think an honest broker is a good role for NASA as these alternatives are presented.

Can we have your assurance that if in the design alternatives that are presented you see either technical, engineering or cost impediments that make the deal "undoable," for lack of a better way to describe it, we can count on NASA as an honest broker to tell us that in the Congress?

Mr. GOLDIN. We will, and we are going to have a peer review of that. We are not just going to be able to, as an Agency, do it ourselves. We are going to have to, in front of the public, undergo a peer review by some of the best minds in this country. So we will provide the data and we are going to give you our best assessment of what we believe.

CRITICAL DESIGN REVIEW

Mr. CHAPMAN. Three weeks ago when you and I had an opportunity to talk, you indicated that the critical design review of the station would continue.

Does that effort continue at NASA now; and if you would, describe for me whether or not there has been any alteration in that activity in light of the redesign effort that is under way.

Mr. GOLDIN. The CDRs are continuing. We are not initiating any major new procurements unless they are critical to the development of a specific subsystem. That activity is on hold, but the CDR process is proceeding. We just completed a CDR, as I understand, at NASA Marshall Space Flight Center. The CDR for work package I is complete.

Mr. KOHRS. Work package 4 was done March 4 and work package 2 will be done Thursday, May 6.

Mr. GOLDIN. So we are continuing on track with the CDR process.

Mr. CHAPMAN. Are any subsystem CDR's on hold?

Mr. GOLDIN. No. All the CDR's are proceeding. We were going to hold making major procurement decisions for cutting some of the actual flight hardware pending the conclusion of the redesign process, but we are proceeding forward with the CDR's.

Mr. CHAPMAN. Let me ask you, without getting into specifics, if there are any surprises at this point, any show-stoppers, or anything you didn't expect in the CDR process to date?

Mr. GOLDIN. So far, I don't know that there have been any show-stoppers. There are a few problems. One pertains to seeing how we could get a backup battery to the present one and trying to see how we can bring it on line and into the schedule. I don't know that we have had any major show-stopper appear to date.

Mr. CHAPMAN. As far as show-stoppers, have any of the problems that you would expect a CDR to uncover go to a flaw in the basic design of Space Station Freedom? Is there anything that would cause you to say we made a mistake way back when that has now been carried forward, that would be extremely costly or take a long period of time to correct?

Mr. GOLDIN. From what has been reported to me, there haven't been any major show-stoppers. I might ask Dick Kohrs to validate that.

Mr. KOHRS. There haven't been any.

Mr. CHAPMAN. During a recent redesign briefing, Dr. Griffin indicated that the current station cost would be very difficult or impossible to reduce from the $16 billion figure to $9 billion without a 50 percent reduction in non-hardware activities.

If that is correct, does it follow that it would be impossible to maintain the jobs that are currently in the program?

Mr. GOLDIN. Well, if we do cut the costs, there will be a reduction in jobs. I don't know how we could do it any other way.

Mr. CHAPMAN. Mr. Chairman, let me reserve some additional questions for later and yield back at this time.

Mr. STOKES. Thank you, Mr. Chapman. Anything further, Mr. DeLay, at this time?

Mr. DELAY. No, sir.

Mr. STOKES. This might be a good time for us to break for the noon lunch hour. We will resume at 2:00 p.m. this afternoon in Room 2358, which is next door.

So we will recess now until 2:00 p.m. this afternoon.

[Recess.]

HEADQUARTERS STAFFING

Mr. STOKES. The committee will come to order. Mr. Administrator, I understand you have a statement you would like to make.

Mr. GOLDIN. Yes, sir. I believe I gave some incorrect information this morning. I referred to the fact that headquarter's head count was going to be reduced by 4.3 percent in 1994. That is not correct. It was 4.3 percent in 1993. We are projecting for 1993 through 1995 to come down 7.7 percent, and that is before we complete the roles and mission study that Jack Dailey is performing right now. So I did want to correct my statement for the record.

Mr. STOKES. All right. We appreciate that very much.

GRAVITY PROBE-B

Mr. GOLDIN. Secondly, I stated that Gravity Probe-B was going to have a Program Management Council review. We have not yet made that decision. It is going to have a nonadvocate review and we have yet to make a decision on the Program Management Council, so again I wanted to correct that for the record.

AERONAUTICS PROGRAM

Thirdly, when we get to the aeronautics budget, Dr. Harris would like to expand upon my response relative to the aeronautics program, and at an appropriate time, we would like to bring him forward so he could expand on that.

Mr. STOKES. We will be bringing him forward at the appropriate time. Anything further on that?

Mr. GOLDIN. No, that is it.

Mr. STOKES. Thank you very much. Off the record.

[Recess.]

LIFE AND MICROGRAVITY SCIENCES AND APPLICATIONS

Mr. STOKES. Let's turn to life and microgravity sciences and applications on page RD5–1.

Mr. Harris, how are you?

Mr. HARRIS. Mr. Stokes.

Mr. STOKES. Good. The request is for $143,900,000 for life sciences and about $89,400,000 for microgravity science. Before I read a statement, we want to pose—and it will take a little for us to develop this for you—I want to acknowledge that there are some Members of Congress, and this subcommittee, who feel that a space station's primary purpose is human physiology. That has not been the emphasis to date expressed by this committee, with the full concurrence of our Senate counterparts.

Recently we have seen a change which you expressed earlier today in the justification of human physiology and that is of medical usefulness. But I do want to say that I believe this new administration wants to build a space station which primarily gives the United States a crack at microgravity research that will enhance the Nation's competitiveness. It is the microgravity experiments that require the peak power requirements, keeping in mind that the Germans and Japanese are primarily looking at the microgravity materials field, so they must feel also that it is important.

When you look at the line item, the life science flight experiments which are increasing from $81,089,000 to $94,700,000 and compare that with the microgravity flight experiment line item which is decreasing from $155 million to $71 million, we see what appears to be a change in priority.

One thing we would like to work on with NASA, however, is a change in the nomenclature for this activity. I am afraid that the title "life sciences" is causing some confusion, because there are many aspects of the life science budget which the appropriations committees, and particularly the Senate committee, strongly supports, including all the cellular biology effort and the biotech work.

On the other hand, as you know, the appropriations committees have not been supportive of the human physiology aspect of the life science budget owing to the simple fact that its purpose has been largely to extend the duration of human flight in order to prepare for moon and mars mission, which this committee has, for more than three or four years, suggested is simply not in the budget cards.

So perhaps one way of recasting the life science nomenclature would be to think more in terms of nonliving versus living activities, but whatever we come up with, some substitution for life sciences is important because it is causing too much confusion.

And I would appreciate, Mr. Administrator, any thoughts you might have on this.

Mr. GOLDIN. With regards to terminology, we will take that challenge. We inside of NASA today communicating with each other have been having a problem in the terminology. Forget about the philosophy. I use the term "biomed" for physiology activities and I use "life sciences" for the cellular activities. But we need a common set of terminology and we will certainly take that as an action. And I think it is a very appropriate action because it will clarify our situation.

I also want to say that we believe we have to have microgravity as part of the program, and I think there is an explanation for the dollar value and I would like to ask Mr. Allison to address that in the general terms and then Dr. Holloway in more specific.

Mr. STOKES. Be pleased to hear from both of you.

Mr. ALLISON. What basically happened from 1993 to 1994 in life sciences flight experiments and microgravity flight experiments was that we took reductions, directed by Congress, which were very heavy in life sciences, also in microgravity. The space station and supporting efforts by that time had been put into the technology package.

We came way down in microgravity in 1993 on the station facilities, put that money into a reserve and were going to apply that reserve in 1994 to offset planned costs. In life sciences, it is up quite a bit from 1993 to 1994 because we have added the MIR mission. There is an increase of about $23 million there for the MIR mission. So it is not quite apples to apples but it is a little better than it looks.

Mr. HOLLOWAY. I would like to address both the budgetary as well as the conceptual area that you brought up. In the budgetary area, you have already heard that outlined and, of course, the overall approach to the budgetary problem this creates is that, as the Space Station comes back on line within the technology package, there should be some restoration so that we hope that in June we will be able to address the problems that exist with regard to looking at that budget and looking at past years and looking at future years. But that really comes, as was suggested by the earlier remarks, out of the technology package.

On the other hand of the operation, I think the need to make clear distinctions is one that we very heavily support within the new office in that we see one purpose in the scientific purpose of the office to encourage the development of laboratory experimental sciences in using the unique facilities that are available from the two elements in space having to do with absolute vacuum and more importantly, the zero-G microgravity condition.

And in that, one of the central organizing conceptual themes that we see that is going to stretch across our various divisions has to do with looking at fluid dynamics in zero-G, both important in living matter and in the various microgravity sciences, and that we will see an emphasis on experimentation on both sides of that.

Of course, some of the biotechnology does have to do with living material in that some of the cell systems are alive, and some of the protein and protein crystal growth experiments also in the biotechnology are not alive.

So we will take the challenge of trying to find some language that more clearly conveys that to you, but we appreciate in the new office the distinction that you draw.

We think that some of the work that needs to be done on what Mr. Goldin just called the biomedical side needs to be undertaken not only because it has something to do with extending duration in space, but because there are essential and critical questions to be answered in areas like bone demineralization that have implications for health on earth and understanding fundamental health phenomena.

Pursuant to that, within that area, with the help of Congress last year and the leadership of Congress, there has been a portion of our budget that has been allotted to NIH, NASA jointly so that with their peer review and their scientists, in anticipation of that

superb group of scientists that are a part of NIH, we have been able to enlarge the basic input into that program and, in a sense, leverage NASA's effort by utilizing another effort that is also supported by the government to advance our capacities in these areas.

So number one, we would like to take the challenge. We appreciate the fact that the opportunity that is afforded is one in which we can do some experiments that will allow us to look both at technologies that are exciting in materials, in fluid dynamics and flame, but also to look at exciting findings on the biologic side that have applications to earth.

When we have had the experience of working for a period of time in zero-G in a space station, we also will have probably answered the question—in fact, I can almost assure you—we would have answered the question which is really critical to the exploratory. That is, can human beings survive productively in low zero-G or do we have to build some kind of artificial gravity, in the more distant future, if we launch some sort of exploratory effort.

So those are very much the spirit of the efforts that we are talking about and that we are thinking about. So we appreciate your challenge and hope we can meet it.

Mr. STOKES. I appreciate your answer to that. Anything you wanted to add, Mr. Administrator?

Mr. GOLDIN. Well, I wanted to just add the fact that, in recognition of the difficult financial times that the Nation is in right now, and in recognition of the fact that we are not ready to launch a mission to Mars, we have terminated the Space Exploration Office at NASA, and we have studies going on in at a very low level in a planning sense.

So I also want to point out that our primary objective, the objectives to bring back technology to Earth, the secondary objective that we will get out of doing our primary objective is, at some point in the future, we will have that understanding. So I wanted it made very clear that that is where we are going and that is our priorities.

RUSSIAN EXPERMENT

Mr. STOKES. We appreciate that. Do we understand correctly that included within the $81,089,000 for 1993, there is $10 million for the Russian experiment?

Dr. HOLLOWAY. Actually, it is slightly more than $10 million, I think, for MIR. In the Life Sciences, it is $25 million.

Mr. STOKES. Did you give us a different figure?

Mr. ALLISON. In Flight Experiments in Life Sciences, the request is $94.7 million in FY 1994, and in that, there is $25 million for the MIR mission; that is an increase from 1993 of $23 million.

Mr. STOKES. The question is for fiscal year 1993.

Mr. ALLISON. There is only $2 million in 1993 for the MIR mission.

Mr. STOKES. Did you have a conversation a few days ago with Mr. Malow?

Mr. ALLISON. Yes, I did.

Mr. STOKES. Did you tell him 10 at that time?

Mr. ALLISON. I told him $10 million and I told him later I thought that the write-up in the book was correct.

Mr. STOKES. So what is in the book is correct?

Mr. ALLISON. Yes, it is.

Mr. STOKES. That is what we need to know.

Dr. Holloway, why don't you go through that paragraph with us. Is it also correct that within the $94,700,000 requested for life science flight experiments in 1994, that $25 million is dedicated to the Russian missions?

Mr. ALLISON. Yes.

Dr. HOLLOWAY. That is correct.

Mr. STOKES. What is the total number of dollars dedicated in all fiscal years to the Russian shuttle, MIR experiments under the life sciences and microgravity budgets?

Mr. ALLISON. $88 million for the MIR mission.

Mr. STOKES. Now, is that split between the two disciplines?

Mr. ALLISON. It is split between Life Sciences, Microgravity, and Spacelab Mission Management.

Dr. HOLLOWAY. Both will be included in that. There are microgravity experiments to be flown.

Mr. STOKES. We need to know the split numbers.

Mr. ALLISON. For Life Sciences, it is $49 million; for Microgravity, it is $16 million; and for Spacelab mission management, it is $23 million. And those total all years, sir.

Mr. STOKES. For sake of comparison, why don't you give us information about how much was dedicated to the United States Microgravity Lab (USML) number one mission which flew last April and how much is dedicated to USML two mission.

Mr. ALLISON. I would have to go through and add that up. Could I provide that for the record.

Mr. STOKES. Sure, for the record.

[The information follows:]

UNITED STATES MICROGRAVITY LABORATORY

UNITED STATES MICROGRAVITY LABORATORY (USML) MISSION COSTS

[Dollars in millions]

Microgravity sciences	115	80
Life sciences	5	7
Mission management	30	38
Total	150	125

Note: USML-2 is not just a reflight of USML-1. Two new experiments have been added and upgrades are planned to others. The cost for microgravity sciences for USML-2 is lower than for USML-1 because some basic hardware paid for and flown on USML-1 will be re-flown on USML-2.

Mr. STOKES. Now, are there any plans for a USML three mission?

Dr. HOLLOWAY. At the present time, within the budget that you see displayed there, there is not. We are hopeful that, as we see the restorations that come out of a Space Station decision, we will acquire more of that run-out budget, and we will see a restoration of that mission. That is the overall purpose in the planning, but it is not there within these cuts.

Mr. STOKES. By the way, is what we have been calling the USML two mission now been renamed the United States microgravity payload one mission?

Dr. HOLLOWAY. No, I don't think so. Not to my knowledge.

Mr. STOKES. Dr. Holloway, the agreement that Congress had with NASA was that the USML missions, of which there were originally intended to be three, was that these missions would be strictly United States microgravity payloads with no foreign participation. Have we changed that arrangement?

Dr. HOLLOWAY. To my knowledge we have not.

Mr. STOKES. In connection with the Russian missions on human physiology missions in general, as you know, the committees have been concerned that these activities lack appropriate external peer reviews. In connection with the upcoming shuttle MIR mission, we understand that that concern was also raised by NASA's own life sciences advisory subcommittee; is that correct?

Dr. HOLLOWAY. The principal question that was raised was whether or not the experiments that were going to be flown on the MIR shuttle missions were going to get reviewed properly. At that time, I happened to chair that committee, the AMAC committee, and we set up an Aerospace Subcommittee to do review for that. The fact is that the mission to date has not sufficiently developed in terms of the completion of the agreements with the Soviets so that there are explicit things to review. One of the things I can assure you of is that we will see that review is carried forward and that appropriate external review is done for all things that are flown.

Mr. GOLDIN. Mr. Chairman, might I add?

Mr. STOKES. Sure, Mr. Goldin.

Mr. GOLDIN. One of the reasons we formed this new office was to bring focus to this whole subject of microgravity and life sciences. Peer review is very, very important and we recognize we have to do more towards that end, and we will.

Mr. STOKES. The committees are in the process of preparing a letter directing NASA to revisit the experimentation selection for this mission as soon as possible and to institute a peer review process for the mission. So I assume we can expect to have your cooperation on that.

Dr. HOLLOWAY. Absolutely.

EARTH OBSERVING SYSTEM

Mr. STOKES. On page RD6–7, request for the Earth Observing System is detailed. NASA is asking for $322,700,000 in 1994, an increase of approximately $60 million above the 1993 estimate. Identify yourself for the record for us.

Dr. TILFORD. Dr. Shelby Tilford.

Mr. STOKES. I note that on page RD6–9 under changes from the fiscal year 1993 budget estimate, there is no explanation or even mention of the reduction that Congress is forced to make because of 1993 budget constraints. That is the reason that the paragraph is there.

Can you tell us why there is no explanation concerning what happened to the $45 million reduction?

Dr. TILFORD. There have been a number of activities, sir, that have taken place over the past two years with respect to the EOS program. If you remember, we proposed the program as a $17 billion program. When it was submitted two years ago, at the recommendation of the Appropriations Committees, there was an $11 billion program presented.

This year, as part of the NASA effort to look at how we might further reduce this system and maintain much of the science, we went through a complete rescoping, which you know as the "red team-blue team" effort. And during this process, we removed an additional $3 billion out of the program. There were a number of activities that took place in order to reduce the $3 billion out of the total EOS program through the year 2000. We would be glad to walk through that in detail or provide that to you separately. Essentially, the main things we did is we reduced the complexity of some of the spacecraft so that we could use a common spacecraft approach. We deleted the High Resolution Imaging Spectrometer (HIRIS) instrument, which was a very high resolution, many-channel instrument from the program on the basis that LANDSAT-VII and LANDSAT-VIII were now going to be a part of the U.S. program. We reduced the number of data products by about 80 percent from what we had originally planned to have available at launch to the point where we reduced that to absolutes in terms of things that we needed. We left in the possibility that these might be reinstated later after we better understood the data reduction.

We had a number of small reductions. There is a slight amount of increased risk in the program. We went to a different parts approach. So, we went through a whole series of exercises in reducing the program by about $3 billion from the program you saw last year.

Mr. STOKES. We may—I want to walk you through a little more of this and we may be a little redundant to some degree, but it is important for us to get it on the record in this way.

The total cost of the Earth Observing System was reduced from $17 billion to $11 billion as part of the 1992, 1993 exercise. Is the $11 billion still the working number or has EOS been reduced on the order of $8 billion?

Dr. TILFORD. It has been reduced to the $8 billion.

Mr. STOKES. At the $8 billion level, what has to come out of the program as we see it before us today?

Dr. TILFORD. From the $11 billion program to the $8 billion program, it is those series of things that I just described that have come out of the program. That is, we removed HIRIS, we cut down on data products, we went to a common spacecraft by after the first AM-1 platform, we went to a common parts list. We reduced the amount of funding to this and a whole series of smaller things.

Mr. STOKES. Are there any plans to reduce it any further?

Dr. TILFORD. Not at the present time, sir. We have a design-to-cost approach. In fact, in developing the instruments, our approach is that, since this is a long-term data collection process, we will work to ensure that the instruments are developed and delivered on cost and unless for any particular instrument, with the exception of one, if that instrument doesn't make it, then we would probably fly without it.

The program is designed to cost. We have reduced significantly the number of instruments; we originally were planning to fly about 30 different instruments on the various spacecraft. Today we are looking at only flying 20 instruments. We do have contributions from Japan, Canada, European Space Agency and perhaps we will have one more from Japan.

So at the present time, we are not today looking at any other reductions. If we want to meet the requirements for the uncertainties described by the Intergovernmental Panel on Climate Change (IPCC), we believe the parameters, based upon understanding those 78 different uncertainties that the IPCC has described, we think this does a reasonable job of doing that, although there are gaps in the program or will be gaps for some of the measurements that are currently going on today.

LANDSAT PROGRAM

Mr. STOKES. On page RD6–19, the budget includes $59,100,000 for the LANDSAT program. Do I understand correctly that the total cost to NASA for this program is $411 million and that is only for the ground portion?

Dr. TILFORD. That is correct, sir.

Mr. STOKES. How much is the DOD contribution to the program in total?

Dr. TILFORD. For the base program, as we have described today, and this is just a duplicate of the LANDSAT–VI program, the contributions by DOD are almost identical to those for NASA. They are well over $400 million. As I say, they are providing the development of the fundamental instrument. We are providing everything associated with the ground system.

This does not include the High Resolution Multi-Spectral Imager (HRMSI) instrument, which is the five-meter pointing instrument which is capable of stereo observations. That is not included in these two numbers that you see.

Now, most of DOD's funding will be spent in development and launch of the systems. Most of NASA's money will be spent over the duration of the program in a sense that this includes the operation cost, data reduction and data distribution, as well as the archiving over the period of the LANDSAT–VII lifetime.

SPACE RESEARCH AND TECHNOLOGY

Mr. STOKES. The table suggests that the exploration technology program and the exploration missions studies program has been eliminated, as has the in-space technology experiment program. I am sorry. We need to turn to space research and technology budget for a moment.

Change players again.

Mr. RECK. Greg Reck.

Mr. STOKES. Okay, Mr. Reck. On page RD7–1, NASA is requesting $298,200,000 for space research in 1994. The table suggests that the exploration technology program and the exploration missions studies program has been eliminated as has the in-space technology experiment program. However, the latter shows up now under the

research and technology base. Also, the space automation and telerobotics activity has been deleted.

And within the $298 million requested, are any activities being carried from those line items showing no funding in 1994?

Mr. RECK. The Space Technology Program was restructured in FY 1993 to consolidate and build along a new program structure that we felt was more closely aligned with our customers. In doing that, the Exploration Technology Program that was shown in 1992 was broken into several pieces but was also reduced in the 1993 budget. In fact, none of that program that is shown in FY 1993 under Exploration—or in 1992 under Exploration Technology is currently carried in the 1994 budget.

We have automation and telerobotics technologies that are included in the Civil Space Technology Initiative Program, and it is identified in the more detailed breakout on the following pages. But the Telerobotics Program that is shown in FY 1992, I believe, also included the Flight Telerobotics Servicer, if that is correct, Gary.

Mr. ALLISON. Yes, it is.

Mr. RECK. And that program was terminated by that year.

Mr. STOKES. Excuse us just a moment. We are looking at page 7, RD7-1. Is the only thing being carried for 1994 space automation and telerobotics, is that the only thing there for 1994?

Mr. RECK. There is automation and telerobotics activities that are carried in the FY 1994 column under the Civil Space Technology Initiative Program.

Mr. STOKES. Is that your only line item?

Mr. RECK. At this point, that is the only line item that we have for automation and telerobotics. There are some fundamental technologies associated with controls, virtual reality systems and sensors that could also be applied to telerobotics that are included in the information and controls element under the R&T base that is up above, but that is very fundamental research.

The focused activities we have in automation technologies and in telerobotics technologies are included in the line that I mentioned, and if you look further at the breakout of that Civil Space Technology line on page RD7-18, you will see a line there that is identified as Operations Technology.

And in fiscal 1994, the budget line is identified as $40 million. There are telerobotics and automation activities included in that line and so that is where they are located.

Mr. STOKES. What is the amount?

Mr. ALLISON. $12.7 million, sir.

Mr. STOKES. Let's turn to commercial programs for a moment.

Mr. ALLISON. Sorry. I made a mistake. There is $32 million in 1994.

Mr. RECK. That is for both automation and telerobotics?

Mr. STOKES. Total of $32 million?

Mr. ALLISON. Yes, sir.

Mr. STOKES. All right. We will have to switch people again, I guess. We are going to another section here.

Mr. RECK. No. I am still here.

Mr. ALLISON. This automation and robotics area could be augmented, Mr. Chairman, through the Tech Package also.

Mr. STOKES. Right. But you don't know how much, right?

Mr. ALLISON. No, sir, not now.

COMMERCIAL EXPERIMENT TRANSPORTER

Mr. STOKES. All right. Let's turn to commercial programs for a moment. On page RD8-1, the request for this activity is $172 million. On page RD8-9, there is a statement in the middle of the page that suggests that both Spacehab and the Comet programs are proceeding successfully.

Now, that statement was written within the last four to six weeks, but what troubles us is that we understand that statement is not correct, that the Comet program, for example, is in serious trouble. It continues to be troubling that the agency seems to be reluctant to want to level with us about these overruns.

What was the total cost estimate for the Comet program?

Mr. RECK. The total cost estimate was $85 million. We now understand, as a result of difficulties associated with the integration of the vehicle that have resulted in a delay in the first launch of that vehicle, that additional costs are being incurred. In this program, our management structure is different from many other NASA programs, in that we are managing the COMmercial Experiment Transporter (COMET) program through the CSTAR, which is a Center for the Commercial Development of Space (CCDS). We have a grant with CSTAR, and under that grant agreement, CSTAR runs a consortium which involves three companies that are involved in this program. So, it is in many respects an arm's length relationship, which is a new way of doing business for us.

As a result, we don't work directly with the contractors in that program but rely on CSTAR for management. CSTAR has been accumulating data on the cost associated with the delays and the problems in integration, and is providing that information to us. We are in the process now of evaluating that information and asking CSTAR to identify options and alternatives for us to deal with what does appear to be an increase in cost.

Mr. STOKES. Let me ask you this. Is the overrun now about $33 million?

Mr. RECK. Yes, $33 million for the total program. That would involve the first three flights of the vehicle. The overrun estimate that we have received from CSTAR for the first launch at this point is $13 million in order to accomplish the first launch, of which about $5.5 million is actual overrun costs to date. But the estimate of the additional costs that would be incurred before the first flight would raise the overrun at that point to $13 million for the first flight.

Mr. STOKES. We also understand that Space Industries, Incorporated, which is the prime contractor, recently halted work on the program. Is that correct?

Mr. RECK. That is correct, the week before last.

Mr. STOKES. Mr. Administrator, this program is beginning to sound like so many of the others that we have had discussions about, and that is, it goes to the whole core of not simply being managed correctly. The justifications would suggest that this pro-

gram is coming along fine, and I would be interested in knowing when you, as administrator, first heard the program was experiencing difficulty.

Mr. GOLDIN. About a week ago, and at that time—was that about a week ago that you came up to my office?

Mr. RECK. Right, right.

Mr. GOLDIN. And at that time, I asked that the people from the Office of Advanced Concepts and Technology (OACT) go collect the data. I was informed of this arm's length relationship and the fact that the contract had been set up that way a number of years ago, that NASA could not just jump right in and get directly to the contractors as we would be assuming full liability for that. So they are going to collect the data and I told them to get back to me very soon because we are expending money. I believe that when we see the data, if the data looks like it does as described, we will immediately trigger the "yellow light system" and make a decision on what we are going to do with this program and then come back to you. But I was informed about a week ago of it.

Mr. STOKES. Notwithstanding that you have this arm's length type of arrangement or transaction, nonetheless, we still wind up paying the bill.

Mr. GOLDIN. That is if we continue.

Mr. STOKES. Right.

Mr. GOLDIN. The overrun is projected to be $33 million over the three flights, and what I have asked the OACT people to look at is what are the various possibilities with one or two flights because we just can't afford to have a program with an overrun with that percentage and to be credible. So they will be bringing the data to the administrator. I am going to then ask Jack Dailey, who is the procurement czar at NASA, to look at it and come back with a specific recommendation, and we will so inform the Congress.

Mr. STOKES. A total of $22,800,000 has been provided for Comet in 1993. Is that sufficient to meet the 1993 launch date, and when is that date?

Mr. RECK. It would not be sufficient with the overrun that is projected. If we maintain the launch date, it will not be sufficient to reach that launch. That way it would require the $13 million that we had indicated in additional funds in order to launch in 1993.

Mr. STOKES. The basic guideline NASA uses for reprogrammings is to take the money from within the area that is affected. In other words, if more money is needed for Comet, it must come from the commercial programs line item. Is that correct?

Mr. RECK. That is correct. It would have to come from another commercial program. There are alternatives that might be available in this case. There is private capital that has been invested by the companies that are involved in the program. They are participants with CSTAR in this activity.

One alternative might be for them to assume some additional responsibility for these overruns. Another would be to adjust the launch date, which is another possibility, or to change the requirements associated with the first launch and there are some options that might be available in terms of the first launch configuration. So we are trying to understand what those alternatives represent in terms of cost.

Mr. STOKES. But now your adjustment of the launch date will not in any way be able to ameliorate the cost overrun?

Mr. RECK. No, not if it is still in 1993.

SPACEHAB PROGRAM

Mr. STOKES. What is the future of the Spacehab program? $66,500,000 has been requested for that activity in 1994 and that will drop to $23 million in 1995. Again, you indicate that the Spacehab program is proceeding successfully. What about the program's future since, as we understand it, NASA does not intend to make a commitment to buy additional space?

Mr. RECK. We have not made that commitment at this point. Our commitment is for two-thirds of the locker space that is available in Spacehab over a total of six flights, and so that means we would have responsibility to purchase 200 equivalent locker spaces.

Our first flight, which is about a month from now, is nearly full in terms of subscription. The second flight is as well. However, a goal of this program was for Spacehab to sell the additional 100 locker spaces to commercial users. Unfortunately, the commercial users have not come forward, and with the exception of one locker space, none of the remaining 100 have been sold.

So we are, again, looking at alternatives at this point to adjust the NASA requirements to ensure that we use our space effectively and fly Spacehab with a full complement of lockers filled as quickly as possible. So we are examining what arrangements we can make with Spacehab and negotiate under the contract to consider moving our payloads forward. So that would be one way of accommodating that to ensure that NASA flies its 200.

However, we still have the remaining issue of not having those 100 lockers filled. And, again, we have to work with Spacehab, consider what the alternatives may be there.

It was an effort to try to commercialize space and to make space available to commercial users via the SSDA agreement with Spacehab, but so far the commercial part of the program has not been successful.

NASA may have additional requirements, but, again, we need to consider if that is what we want to do in utilizing this asset and we have not made that decision at this point.

Mr. STOKES. What are some of your options there in that respect in terms of the 100 users?

Mr. RECK. With respect to the 100 lockers, the options would be to consider whether we have additional payloads that we would like to fly to utilize that space. However, our concern right now is centered around the third flight of Spacehab where we have now planned for at least 30 locker equivalents and 120 would be available. We are considering whether or not to move our payloads forward from subsequent flights to fill that remaining space, and at the same time we need to work with Spacehab to understand what happens if no additional commercial payloads come forward.

Mr. STOKES. I guess when you look at the action of the committees in Congress, we have fulfilled our full commitment in terms of 1994, 1995, and everything we look at at this juncture gives indication in fact that Congress may have to put up additional money.

And the question is whether we should do that, whether we should pull down or pull back from it at this point. Any comment on that?

Mr. RECK. I think that is a very real consideration and that is exactly what we are looking at as well. Assuming that no additional commercial payloads come forward in Spacehab, we need to determine exactly what and how NASA might use that asset. Under the terms of the arrangement, we can fly our 200 payloads or locker equivalents and not carry it any further and that would fulfill our commitment. Or we could consider an alternative, which is to use the asset if that is in the best interest of the Government. So those are the options that we need to consider at this point.

Mr. STOKES. Mr. Administrator, do you have any comment in this area?

Mr. GOLDIN. Yes. I believe that this is an area that is precisely along the lines that I spoke about when we talked about the reforms. I think this is an area where we have to have candid conversations with our contractors and our employers, and the intention of this was to have a solid commercial venture.

I don't believe it is going to be in the interest of the U.S. Government if we just privatize the Spacehab where the Government is 100 percent of the customer. So we are going to have to work with the Spacehab people and see if there is any way that NASA could help them get commercial payloads because that was the intent.

If we can't get commercial payloads, I don't think the Government ought to be in the business of subsidizing a venture that doesn't pan out. But we do have an obligation to work with them to see if we could help them get some more commercial payloads and we will do that. But if we get to a point where we cannot make that happen, I think it is appropriate to fish or cut bait.

AERONAUTICAL RESEARCH AND TECHNOLOGY

Mr. STOKES. We appreciate the comments from both of you in this area. We now turn to aeronautical research and technology. We need to change players again. Dr. Wes Harris. This is the aeronautical research and technology area where NASA is requesting $1,020,700,000 in 1994. That represents a major increase above the 1993 level of $865 million.

I think the committee would applaud this increase, and I would hope to protect it at all cost regardless of what our allocation is, because we think aeronautics is one of the last industrial areas that this nation still enjoys a lead.

I am wondering if there are additional potential funds for aeronautics within the technology package carried under the 1994 $2.3 billion request for the space station program.

Mr. HARRIS. There are several potentials within that, Mr. Chairman, including initiatives that may lead to the establishment of our technology institutes, one, at the Langley Research Center in Hampton, Virginia; another at the Ames Research Center in Moffett Field, California. The Langley resource would be focused on aeronautics; of the Ames Research Center at Moffett Field would focus on information sciences.

HIGH SPEED RESEARCH

Mr. STOKES. On page RD9-16, under the systems technology programs, the high-speed research budget increases from $116,995,000 to $187,200,000. What will be the 1995 and 1996 numbers for that line item?

Mr. ALLISON. In 1995, Mr. Chairman, it is $236 million and in 1996, it is $251 million.

Mr. STOKES. Would you break out for the record the dollars in 1993 and 1994 for that line item by center?

[The information follows:]

HIGH SPEED RESEARCH PROGRAM

The estimated Center distribution of the High Speed Research program in FY 1993 and FY 1994 is provided below in millions of dollars:

	FY 1993	FY 1994
High-Speed Research Total	117.0	187.2
Ames Research Center	11.3	23.9
Lewis Research Center	71.0	90.7
Langley Research Center	33.1	70.3
Headquarters	0.6	2.3
Goddard Space Flight Center	0.4	.....
Jet Propulsion Laboratory	0.6	.....

PHASE I AND PHASE II EFFORTS

Mr. STOKES. A discussion of the high speed research program is carried on pages RD9-31 through RD9-35.

On page RD9-32, you note that the Congress added $25 million to the Phase Two effort. Does the Phase Two effort represent the full $116,995,000 in 1993?

Mr. ALLISON. We do have $117 million in 1993 for both phases, Phase One and Phase Two, with $25 million that was added in Phase Two.

Mr. STOKES. All right. How is that split up by engine work, airframe work, and so forth?

Mr. HARRIS. That crosscut, sir, we will have to get back to you for the record.

Mr. STOKES. All right, for the record. Also provide for us what is the same breakout of the $187 million requested for 1994.

Mr. HARRIS. Yes, sir.

[The information follows:]

HIGH SPEED RESEARCH PROGRAM

A breakout of the High-Speed Research Program for FY 1993 and FY 1994 by major area is provided below in millions of dollars:

	FY 1993	FY 1994
High-Speed Research Total	117.0	187.2
Atmospheric Effects	12.2	11.1
Emissions and Source Noise	29.7	25.7
Community Noise and Sonic Boom	17.7	14.5
Enabling Propulsion Materials	37.0	48.3

	FY 1993	FY 1994
Critical Propulsion Components	9.2	19.0
Airframe Materials and Structures	11.2	27.5
Aerodynamics		16.2
Flight Deck Systems		7.7
Technology Integration and Environmental Impact		6.2
Environmental Research Aircraft and Remote Sensor Technology		11.0

Mr. STOKES. I note on page RD9-33 you indicate that Phase Two is planned as an eight-year effort. Is the first year of that effort 1993?

Mr. HARRIS. Fiscal year 1994 to start, sir. The exit from Phase One completes this current operating year. Fiscal year 1994 starts Phase Two, although $25 million was provided by Congress in 1993 to "Jump Start" key Phase Two technologies.

Mr. STOKES. Do you anticipate that it will take eight years before a decision can be made on the environmental question, whether to proceed with the development of a high-speed transport?

Mr. HARRIS. The criteria for the move from Phase One into Phase Two is that we have driven risks down substantially, to a level where we feel comfortable that we can meet the emissions criteria—that is not to harm the ozone layer—that we can build the engines that will allow us to operate within the noise limits projected for the year 2000, and that we will have capability to reduce the sonic boom appropriately.

Mr. STOKES. Dr. Harris, what is the earliest under this program you think that a determination can be reached as to whether to go forward in terms of building it?

Mr. HARRIS. I would think that near the turn of the century, the 1998-1999 timeframe, we would be sure that we can do all of the technologies.

Mr. STOKES. And then to make the decision to go forward?

Mr. HARRIS. Yes. NASA would have driven the technology risks to a minimum at that point, which would allow industry to decide to design and construct a prototype.

ADVANCED SUBSONIC TECHNOLOGY

Mr. STOKES. Now, on page RD9-36, you are requesting $101,300,000 for advanced subsonic technology. That is almost a ten-fold increase. What is the total cost of this effort and what is the principal product of the subsonic research?

Mr. HARRIS. I will answer the second part first.

Mr. ALLISON. $1.2 billion is the total cost, Mr. Chairman, through run-out.

Mr. STOKES. All right.

Mr. HARRIS. Mr. Chairman, although we have a very aggressive and I believe a very successful program in the high-speed arena, leading to a future high speed civil transport, the new SST, we must also have a balanced program that reflects adequately the largest share of the commercial market, namely airplanes that fly subsonically.

In order to do that, we have developed this particular initiative working very closely with industry. It will respond to needs to

insert technology into the existing fleet. It will respond to needs to improve airport capacity, to improve airport safety, to respond to issues of icing, to respond to issues of aging aircraft, to be aggressive about the potential that exists at the low-speed area involving rotor craft technology, including tilt-rotors and tilt-wings, as well as to transfer additional technologies to the GA general aviation area. So this is a very comprehensive program that looks at the airplanes, it looks at the operation of the air system, it looks at the operation of the airlines, it looks at questions of safety as well as the environment.

NATIONAL AERO-SPACE PLANE

Mr. STOKES. On page RD10-1, we see that the National Aerospace Plane is back for another attempt. The request is $80 million in 1994, which is identical to the $80 million in 1993 that we were unable to fund on a priority basis because of our budget problems.

Do I understand correctly that the DOD part of this funding as carried in the 1994 budget, is only $40 million?

Mr. HARRIS. It is $43 million.

Mr. STOKES. In order to make this new effort work, doesn't the DOD level have to be more like $120 or $130 million?

Mr. HARRIS. That certainly would be desirable.

Mr. STOKES. How does the new NASP program differ from the program we funded for some years?

Mr. HARRIS. The program differs in the following way: It is designed consistent with the Defense Science Board review of the program in order to drive down risk with three critical experiments which will be performed using existing ICBMs.

The first experiments will examine the growth and behavior of a hypersonic vehicle. The second set of tests will look at the propulsion of a scramjet at high Mach numbers, Mach numbers on the order of 12 to 15. And in the third series of experiments, still using existing boosters, we will look at performance, stability and weight considerations of a hypersonic airplane. Those are the three critical experiments. We must be successful in understanding those phenomena before we proceed to design this airplane and hence allow industry to move forward with the construction of it.

Mr. GOLDIN. Mr. Chairman, if I might just add——

Mr. STOKES. Sure.

Mr. GOLDIN. The program we were on was to build a $10 to $15 billion aircraft before we resolved the fundamental technical issues that Dr. Harris is talking about, and we couldn't find out the solutions to those problems until we expended $10 to $15 billion. I believe the program that Dr. Harris is describing is a much sounder one and in keeping with the spirit of our trying to reform NASA—that is to do a series of technological experiments to bound the risk before we commit to a prototype aircraft, rather than building a prototype aircraft first and then finding out what the risk is second. So this was designed to be a very critical technology, high risk technology, high payoff, but we cannot do it alone and we are going to have to have the support of the DOD. We have talked to the DOD. Dr. Gibbons has also sent a letter over to the DOD indi-

cating the priority that the White House puts on this program, and they are exploring ways of finding increases in funding to do it.

Mr. STOKES. What you have just touched on, of course, would be a large part of the concern of the members of this committee, and that is in terms of the contribution of DOD. And I think it would have to be substantially more than is currently being projected.

In that vein, in light of your negotiations and conversations with the White House, is it reasonable that we could anticipate an amendment that would increase the DOD contribution up to much more like the figure that we discussed with Dr. Harris?

Mr. GOLDIN. I believe there is a high possibility for that to occur and discussions are going on right now.

HISTORICALLY BLACK COLLEGES AND UNIVERSITIES

Mr. STOKES. On page RD13–1, NASA is requesting $23,200,000 for the minority university research and education program. We better switch again.

Mr. GOLDIN. You are getting to meet the whole team.

Mr. STOKES. That is good.

For the record, Dr. Yvonne Freeman.

Dr. FREEMAN. Thank you.

Mr. STOKES. All right. On page RD13-4, the agency is requesting $12,200,000 for Historically Black Colleges and Universities (HBCU). The justifications note that special emphasis will be placed on enhancing the math and science abilities of students at these universities.

NASA has been funding this program at about this level for the past two to three years. Tell us, how do you measure whether you have had some success in 1992 and 1993 in encouraging students at these universities to enter the math and science disciplines?

Dr. FREEMAN. Let me first for the record indicate that I have served as the university research director for three Federal agencies—USAID (Africa Bureau), NASA, and the Department of Agriculture—and a NASA Federally Funded Research & Development Center, the Jet Propulsion Laboratory, prior to my appointment as the Associate Administrator for Equal Opportunity Programs.

Having said all that, I would like to acknowledge that NASA has had a very robust program, working with minority universities, which includes Historically Black Colleges and Universities as well as other minority universities.

With regard to the kind of progress we have made over the last few years, I think our progress has been exceptional in that we have developed a number of outstanding research and development and training initiatives. We have established a number of Science & Engineering scholarship programs at historically black colleges, tribal colleges and other minority universities throughout the country. We are currently servicing about 1,500 students in those college programs.

These programs should operate as feeders for the NASA workforce at some point. Subsequent to their completion of the Science & Engineering training activity, we expect that they would be invited into the NASA work force or pursue graduate training programs which are also referenced in the justification here.

The total amount of money as you indicated, $12.2 million for 1994, is augmented by the institutional program offices, which in effect provides us a budget of approximately $22.5 million for HBCUs, in fiscal year 1994. Similar planning and program augmentation is planned in support of the Other Minority University programs specifically include the Hispanic serving schools as well as the tribal colleges.

At the Historically Black Colleges and Universities we have provided for infrastructure development. We have also provided for the establishment of Centers of Excellence, which enable faculty at historically black and other minority universities to engage in real time research working along with NASA researchers, technologists and engineers at the various NASA centers, as well as publishing papers and perhaps having an opportunity to translate some of their understandings in terms of the science enterprise, as NASA defines it, into commercial endeavors, et cetera.

So it is a robust program. It represents, I think, less than 4 percent, however, of the total higher education expenditure.

Mr. STOKES. How many of the historically black colleges and universities are participating in the program?

Dr. FREEMAN. Currently, as you probably are aware, there are 117 historically black colleges. The HBCUs represent a little less than 5 percent of the total university universe. We have seven Centers of Excellence that are funded at approximately $10 million across the seven centers. In addition, we have several other schools that have training programs. I would suggest we have approximately 26 schools that are involved in NASA training efforts and research efforts in total.

Mr. STOKES. Geographically, in terms of their location, would you say they are——

Dr. FREEMAN. Well, as you probably are aware, most of the historically black colleges are located in the southeast region.

Mr. STOKES. We have the oldest in Ohio.

Dr. FREEMAN. We have several institutions located in Ohio, Central State University and of course, Wilberforce, and we recently established a training initiative; we have established a Scientific Data Visualization Center at the Central State University in Wilberforce, Ohio, which is our outstanding initiative that is supported by the Jet Propulsion Laboratory (JPL).

JPL, through the collaborative support of OSS, has provided a scientist on faculty loan to Central State to spend a year or two at this institution to translate and transfer the scientific data visualization expertise and software to the institution, building therein a capability so that students and faculty can become involved in data development and acquisition activity.

In addition, I think it is important to point out that subsequent to that establishment, MIT, Ohio State University, Carnegie Mellon, UCLA and USC have joined that effort and will translate those skills likewise into a supercomputing effort.

Mr. STOKES. You had mentioned Wilberforce. I had the pleasure of being present when Administrator Goldin announced the Wilberforce grant, Dr. Julian Earles at NASA and the President of Wilberforce. And I want to highly applaud what is being done in this area.

I don't know how we can look into the year 2000 and beyond and realize the demographics that are going to be occurring in this country without the type of effort that you are involved in here, talking about the fact that we already know, for instance, that in the year 2000, that one-third of the new entrants in the workplace will be minorities and that by the year 2020, fully 40 percent of the workplace will be minorities.

So it is necessary that we become involved at this stage, being this close to the year 2000 and beyond, with these type of increments in a program of this sort. So I applaud the administrator for his efforts in this regard and we fully support what is being done here.

GRADUATE STUDENT RESEARCHERS PROGRAM

On page RD13-7, the justifications note that fiscal year 1992 was the sixth year of the graduate student researchers program. The funding has remained relatively stable at about $3,300,000 and the justifications indicate that the money will support an additional 70 students in 1994.

In total, what is the number of students that will be supported including the 70? Is that about 200?

Dr. FREEMAN. In 1993 the total is about 180 students. We had 118 in the 1992 program year and we have been increasing it by approximately 75 per year.

Mr. STOKES. How many could be supported if more funds were available?

Dr. FREEMAN. Well, the average level of support for students in the graduate researcher program is $22,000, which is fairly consistent nationally with other graduate researcher programs. We could support substantially more students if there was substantially more money and therein provide the infrastructure and the support that the country needs to maintain its preeminence in science and engineering.

Mr. STOKES. All right. Let's now turn to space transportation systems budget.

Mr. GOLDIN. Before we go to space transportation, if it might be possible, Dr. Harris wanted to make some comments with regards to aeronautics.

HIGH SPEED CIVIL TRANSPORT

Mr. STOKES. I recall that you did indicate that and we said we would reserve time for him to do so. We recognize you at this time.

Mr. HARRIS. Thank you.

Congressman Lewis from California raised a question that I will try to paraphrase. He asked Administrator Goldin what other than fiscal resources over the next five years can prevent the U.S. from being first in the high-speed civil transport competition.

And I would like to add to Administrator Goldin's comments the following. I firmly believe that the FAA, the Department of Commerce, working with international organizations, must set international standards on emissions, on noise and sonic boom. I also believe, with equal intensity, that the U.S. must take the lead and must maintain international leadership in determining the total

system environmental constraints. At NASA, we must take the lead to stimulate and support the appropriate Federal agencies to complete this task. If we fail to be the dominant force in setting the environmental constraints worldwide, we still may lose the competition. That is equally important as being able to produce an engine that will not harm the environment, that will not violate noise standards. We must be active in that arena as well. So it is not all about money, it is not all about technology. We must be active in that dimension as well.

Mr. STOKES. We appreciate that and we certainly agree with you.

Mr. GOLDIN. We had one more request from Dr. Freeman to just add a little to the testimony she made.

HISPANICS PROGRAMS

Mr. STOKES. Sure, Dr. Freeman, be pleased to hear from you.

Ms. FREEMAN. We have been speaking largely about the historically black college involvement in this testimony. I wanted for the record to acknowledge what the agency is engaged in trying to increase the presence and participation of Hispanics and Hispanic Serving Institutions (HSIs) in all of our Minority University and equal opportunity programs.

It is important for this committee to appreciate that we support a NASA Science & Engineering training project at the University of New Mexico (UNM), and the University of Texas at El Paso (UTEP) I addressed the closing ceremony at the UNM program last Friday. There are approximately 100 Hispanic-American students in UNM effort who have an average GPA of 3.5, many of whom are graduating this year and will move into graduate schools into the NASA workforce, and elsewhere in the country. The UNM program is an outstanding program and it is in its sixth year. The UTEP effort is relatively new, and it is important for the committee to appreciate that.

Additionally, we support over 3,000 Hispanic students in our precollege programs throughout the country. I know Congressman Torres had some concern about what initiatives are we providing for Hispanics. I submit outreach in this area is really substantial. Some of the participating academic institutions in our Hispanic Institutions include New Mexico Mesa, California State University at Los Angeles, Texas Southmost College, New Mexico Highlands University, University of New Mexico, University of Texas El Paso and New Mexico Highlands. New Mexico Highlands is important because it also enjoys a science alliance, with North Carolina A&T State University, a historically black college, where we try to develop teaming arrangements and encourage collaboration between Hispanic serving and historically black colleges and universities in the development of research and training efforts. We also have efforts at the National Hispanic University and University of Turabo in Puerto Rico and the University of Mayaguez.

We have been talking more recently with the Hispanic Association for Colleges and Universities (HACU), and their Director Rafael Magallon, who has expressed an interest in establishing a parallel initiative similar to that we share with the HBCUs.

More recently, the Administrator and I have met with Mr. Magallon and other staff at HACU to define a five-year plan which would enable us to provide similar kinds of research and development support, training support, faculty awards for research, institutional program research for the faculty and students at the institution, at Hispanic serving institutions.

Hispanic serving institutions are institutions that have a minimum 25 percent Hispanic student population. The committee should appreciate that 45 percent of the post-secondary students who are Hispanic in the country who are attending college are attending Hispanic serving institutions. We are involved in that effort as well. JPL, likewise, has a Hispanic initiative (CUESTA) at the University of Texas at El Paso, as well as at Cal State University Los Angeles.

One final comment is that we have six Hispanic members on our Minority Business Resource Advisory Committee. They are Nancy Archuleta, Lantz Balthazer, Carlos Esparza-Carlos is the director of Federal liaison for the Hispanic Association for Colleges and Universities (HACU). Miss Belinda Guardarma, Miguel Hernandez, and Alfredo Teran. We are very pleased to have these individuals providing guidance and counsel to us as we develop initiatives with Hispanic serving institutions and the tribal colleges.

Thank you.

Mr. STOKES. Thank you. We will see that the information provided by Dr. Harris and yourself is made available to Mr. Lewis and to Mr. Torres. You may also want to give Mr. Torres a briefing with reference to this program.

Ms. FREEMAN. We would be pleased to.

SPACE SHUTTLE PROGRAM

Mr. STOKES. Thank you very much.

We now turn to space transportation systems budget. General Pearson, pleased to have you with us.

We now look at page ST-1, the request for the Space Shuttle program is detailed. NASA is requesting $4,196,100,000 for the shuttle in 1994.

Although that number is up slightly from previous years, it is actually less than 1992. I am wondering if most of that reduction is attributable to savings in the shuttle program. General?

General PEARSON. Yes, sir, it is. And most of it is attributable to Launch and Mission Support, which is the processing and rehabilitation of the external tank.

ACCESS TO SPACE

Mr. STOKES. On April 8th, Mary Kerwin wrote myself and Senator Mikulski and described the "Access to Space" study now under way, which, in part, was requested by the committee last year.

The purpose of the study is to assess and design a long-term plan to meet NASA's and the Nation's requirements for getting to space through approximately 2030.

Three broad options are being considered. In summary, these are, one, retain the shuttle as the primary means of access to space until the year 2030; two, retain the shuttle until approximately

2005; three, retain the shuttle until an unspecified date in the early 2000s.

The latter option is known as the "leapfrog" approach designed to capitalize on advances made in the National Aero-Space Plane and new technologies from other programs to achieve order of magnitude improvements in the cost-effectiveness of getting into space.

I think it is fair to say that Congress has not been overly enthused with the NLS program and its antecedents, and may not be very impressed with the new name for the program, the "spacelifter."

One of our concerns, I think it is fair to say, has been all of the ALS/NLS/Spacelifter technology does not really get at the problem of significantly reducing the cost of taking a pound of payload to orbit, and perhaps we should be examining the "leapfrog" approach, which would involve significant technological breakthrough.

Mr. Administrator, how do you react to this question, given the fact that our resources are so very constrained? And I am wondering if it really makes sense to spend $10 billion to develop an NLS type vehicle rather than spending the money to "leapfrog" to a new launch technology.

Mr. GOLDIN. Mr. Chairman, we share that concern and in fact it is our intent and approach at this point in time to say we want to have a pause for a few years to really sort out the right way to proceed with this. We are very concerned about the launch capability and access to space in the United States.

The Europeans have made a very significant investment in their next generation launch vehicle. The Russians have very low cost launch vehicles. The Chinese have low cost launch vehicles. And we just can't spend billions of dollars to come on line five and seven years later with something that, at best, would be parity.

So what we are proposing to do here is not to launch forward on a $10 billion investment, but to spend a few years sorting through and coming up with a strategy that doesn't give us parity five years later but gives us a capability that leapfrogs. So we are going to have to really spend time and sort through what our options are and we are not proposing a major expenditure in this area until we understand where we want to go.

Again, this is in keeping with the philosophy we stated during the hearing before you last month, and we will work with the DOD. But NASA, at this point in time, is not ready to commit to the Spacelifter. So we concur with your concerns.

Mr. STOKES. Thank you. In the letter received on April 8th, NASA indicated that although the study is not anticipated before mid-summer, that you would keep the staff apprised of the progress.

I would like to ask Arnie Aldrich what the study has revealed so far and are there any indications about which option seems the most workable, given the current budget constraints? Mr. Aldrich?

Mr. ALDRICH. Mr. Chairman, I am very enthusiastic about this study, that I am leading, and concur in the comments already made by yourself and by the Administrator. We are pursuing each of the three legs that you mentioned, the Shuttle, the NLS type de-

rivative complete system, and the new technology leapfrog. Each of them can produce a promising way to go if we invest in that path.

And we are moving now from a study of the options into pricing, costing and technology maturity of the options. And until we know what the costs are and what the trades are, it would be hard for me to say which option is the most likely to be recommended.

I am very enthusiastic, though, about the leapfrog new technology option. It is considering both single stage to orbit and two stage to orbit systems. It is considering air breathing and rocket systems and the two in combination. And there have been advances in technology that frankly I think NASA has not studied carefully enough in recent years and we will have a very positive candidate in that area.

I don't know yet what the technology development plan will be that goes with it and I don't know what the cost projection will be, but we are targeted to be reporting to the Administrator by early July, and I certainly am prepared to report to Congress on status prior to that time. We will definitely be giving you a full report after we complete the assessment.

Mr. STOKES. Following the report, can you give us any indication of when you think the White House might make some decision?

Mr. GOLDIN. I don't know. They were planning on reporting out to me. I was going to go forward to the White House and go through with a discussion with them.

The other thing that we are going to do is with the military, DOD is our partner in access to space. For NASA to develop a separate vehicle, the military to develop a separate vehicle, and then leave our U.S. commercial industry with yet a third vehicle, on a national basis I don't think would make sense.

So I think it is very appropriate that we take the time to coordinate with the DOD. General Horner out at Space Command is very, very positive about working with NASA and the commercial industry. NASA wants to work with the commercial industry also.

So the process that I would foresee is, as soon as we get the input from Arnie Aldrich's team, we will coordinate with the DOD and the commercial industry. We want to get their inputs because America can't afford to have, as I said, have three separate vehicles. After that coordination occurs, I think then it is appropriate for NASA to take it forward to the White House. Now this may take a little extra time, but I think we will be united as an industry and as a country in terms of what way we go.

Mr. ALDRICH. Mr. Chairman, I would like to add to that. I have several members of Air Force and DOD on my steering committee and also a member from the Department of Transportation. DOD is conducting a similar study at this time and there is a key representative from my office on their Steering Committee. So we are attempting to be well-coordinated and informed about each of our processes as we work towards this goal.

Mr. STOKES. I appreciate that.

DOD AND NASA WORKING TOGETHER

Mr. LEWIS. Mr. Chairman, could I just interpose here?

Mr. STOKES. Certainly. I recognize you.

Mr. LEWIS. I focused on the $10 billion question. This is a program that successfully was completed as I understand it.

There was originally, this year, a request for 250 million. 125 DOD, 125 NASA, is that right? Or is that 1993?

Mr. GOLDIN. That was in 1993, that was not in 1994, sir.

Mr. LEWIS. Okay, that is right. These figures indicate that you have got zero for 1994, DOD has got 53.9. On the other hand, I gather that under NTI, if there is funding there, one of the areas involves launch technology, which would suggest that you would plan to do some funding through NTI.

Mr. GOLDIN. Yes, and it would be our hope and expectation it would be on the same order of magnitude as the DOD funding, but the effort and focus would be on technology to establish risk reduction before we proceed forward with the program, rather than saying we are proceeding on this particular program and then commit to the $10 billion before we have convinced ourselves that we know what direction we are going in. So it is a little bit different thrust in the DOD right now.

Mr. LEWIS. Mr. Aldrich, are you confident about being able to actually coordinate with DOD?

Mr. ALDRICH. Yes, now.

Mr. LEWIS. Go ahead. That would be the first time I have actually heard that being done successfully. They don't coordinate with each other, let alone with some other agency.

Mr. ALDRICH. Well, we have tried for the last several years to work quite actively with DOD with success.

Mr. LEWIS. The active phrase is we have tried.

Mr. ALDRICH. But you have got to recognize, when it gets down to the hard decisions, their requirements and their vision of their future needs and those of NASA haven't coincided well enough to ensure that our programs are coordinated well enough to result in a program that we are now all working on. We need to go back and do some more homework.

Mr. LEWIS. I certainly hope you would let this subcommittee know if you really find some major stumbling difficulties. I think you will find difficulty, but it is clear we don't need to have two or three such programs moving to a $30 billion lack of conclusion rather than a 10.

Mr. GOLDIN. Congressman Lewis, we are committed to doing that. I would like to indicate to you that in my past career, I have had a long working relationship with Dr. Perry, who is the Deputy Secretary of Defense. I have had a working relationship with John Deutch, who is the chief acquisition official for the DOD. And on a personal level, I have already met with General Horner. I have worked with most of the generals, and we are going to act as Team America.

By the way, I have a little hat here, which says U.S.A. It was given to me by the employees of Johnson Space Center—the ones I referred to this morning—who are all turned on about working on the Space Station. And on it, it has a little button which says "No Whining." And it has eyes that they put in the front here so we are going to look forward, and it has eyes on the back that says we are going to learn from our past history. They presented this to me, and I promised them that I would show that to this Committee,

to say that we are serious about working for America and not working for the interests of NASA. That is the message of that hat.

And that is what we are going to do in working with the DOD. We cannot afford to have NASA go in one direction and the DOD go in the other direction. We have got to satisfy the needs of the Nation. And I know if you speak to General Horner, he speaks very positively about working with NASA. So I think you have a very serious intention this time. And if we do have problems, we are committed to coming back here.

Mr. LEWIS. Thank you, Mr. Chairman.

MIR MISSION

Mr. STOKES. On page SF1-4, the orbiter operational capability is detailed. The budget requests $53 million for the MIR mission.

What is the total cost of the MIR mission carried in the space flight account?

General PEARSON. We are carrying a total through all the years of $135 million.

STRUCTURAL SPARES PROGRAM

Mr. STOKES. On page SF1-6, the Structural Spares Program is discussed in the justifications.

In a letter from the Inspector General to the Committee Clerk on March 24th, I note that his recommendation is, and I quote, "NASA does not have a mission requirement for an entire set of structural spares, and by canceling the structural spares contract option, it could avoid between $471 million and $618 million of planned costs."

The request for structural spares in 1994 is $35 million. Including that funding, how much has been appropriated for this set of structural spares to date?

General PEARSON. To date, it is about $600 million. But you will notice, sir, that we have changed philosophy in that we are just funding high-risk spares, like elevons, landing gear doors, and that type of thing that might be damaged rather than big-end items like aft fuselages and things like that.

Mr. STOKES. All right. Can you give—we need the total on those.

General PEARSON. 499, 57, 6, and 35.

Mr. GOLDIN. You will excuse my comptroller who refuses to use an electronic calculator and still does it by hand.

Mr. ALLISON. It is $597 million to date.

Mr. STOKES. As we recall, the set of structural spares that eventually became Orbiter 105, following the accident, cost NASA approximately $425 million; is that correct?

General PEARSON. I thought it was more than that.

Mr. ALLISON. I thought it was——

General PEARSON. For Orbiter 105, the total was like $2.1 billion, but we came in about $200 million less than that.

Mr. STOKES. Okay.

Mr. GOLDIN. No, he is just talking about the spares.

Mr. STOKES. For the spares.

Mr. GOLDIN. We will collect that data and report it for the record.

Mr. STOKES. That would be fine.

[The information follows:]

OV-105—STRUCTURAL SPARES

The structural spares that were used on OV-105 (Endeavour) began in FY 1983 and completed in FY 1990 for a total cost of $391.6 million.

Mr. STOKES. What is the total estimated cost of this set of structural spares, and if we adopted the IG's recommendation, what would be the total savings? Is it the $471 million noted in his letter?

General PEARSON. Again, I would have to come back to the record on that. But I don't think it is quite that much. We have come down from about two-thirds of what we were spending on structural spares to a half.

Mr. STOKES. What we need here is the total estimated cost of the set of structural spares.

[The information follows:]

STRUCTURAL SPARES TOTAL COST

The estimated total cost of the current set of structural spares is $375 million. The current estimate is significantly reduced from the program we proposed in the FY 1993 President's Budget which was approximately $618 million. This current estimate is $243 million less and reflects the decision to complete only those spare structures that are considered to be of "high risk." High risk in this context means those structures that are most likely to become damaged during operations such as landing gear, body flap, wing parts including ailerons, payload bay doors, etc.

The Inspector General observed that we could save between $471 and $618 million in reducing or canceling structural spares. We believe our FY 1994 request reflects the intent of his recommendation to reassess the need for structural spares.

Mr. ALLISON. Mr. Chairman, we are not funding a set of structural spares anymore. We have an ongoing line to fund individual high-risk spares now. And we are just level funding at about $35 million a year.

General PEARSON. And the philosophy behind that is we don't know exactly where we are going now. You have to help us with this and we are keeping that capability with what we might use in an emergency, and also keep the skills going until we determine after the access to space study where we are going with the orbiter.

Mr. GOLDIN. We will come back for the record, and let me tell you how I propose to answer this question. We are not on the path that would have led to the $400 to $600 million number that the IG indicated in his letter. We have cut way back. And what we will come back and talk about is, given the new philosophy we have on structural spares, exactly how much we plan to spend over the next five years, I think that is the number that you ought to see and be able to compare that number to the projection that the IG made. And I think you will see a much smaller number now.

Mr. STOKES. For the record, I think what we really would like to get to, Mr. Administrator, is the first set of spares cost us about $450 million. And that was a complete set. And of course what you have just talked about here today is $553 million–$593 million. And a continuing cost of $35 million a year.

And I guess our question is, what did we get for it and why does this continue to go on and on and on?

Mr. GOLDIN. Basically it is an insurance policy to keep the line open, because once those skills go away, we will not have them. And in order to get something for that, what Jed is saying is, we are building up an inventory of critical hardware that we could use, that we would have to replace and we wouldn't have time to replace it had we shut the line.

I believe that right now we are going to be in this situation because we will not be making a decision on the Shuttle in less than a five-year period. I wouldn't want to lead the Committee to believe that NASA would be ready to make a decision to say we are ready to transition from the Shuttle until we go through this technology development activity, understand where we are going, and then are sure when we can commit to a new launch vehicle.

So given that we are going to have the shuttle with us at least for a decade, we believe it is prudent to keep that line open, to have available in case we need it. And what Jed is trying to do is throttle that line down to as low a dollar value as possible, while still keeping the critical skills available. That is the thrust of our philosophy.

NASA INDUSTRIAL PLANT—DOWNEY, CA

Mr. STOKES. Now, the IG also indicates in his letter, and I want to quote again, "Because no additional orbiters are planned, the NASA industrial plant at Downey, California, is no longer needed. NASA could reduce future occupancy costs $50 million annually and avoid $55.5 million of planned facility improvements in fiscal year 1992 through 1998 by closing the Downy facility."

Do you agree with the IG's assessment?

Mr. GOLDIN. I would like to ask Jed to deal with that.

General PEARSON. Yes, we do agree with that. And we have been seriously looking at this issue along with the structural spares and keeping the people, the capability to make another orbiter. But we have to defer that until we discover where we are going in the future here. Because if we shut them down now, I am not convinced we will save all the money that is indicated in there, but we lose the capability and the flexibility that we need at this particular moment, especially in all the adjustments we are doing here in the next two few months.

Mr. STOKES. I wonder if we could ask the IG to comment on this area. Mr. Bill Colvin?

Mr. COLVIN. Yes, sir.

Mr. STOKES. Mr. Inspector General, we are pleased to hear from you on this.

Mr. COLVIN. I am pleased to be here, Chairman Stokes. And what can I specifically answer for you on those questions?

Mr. STOKES. Well, I guess basically we would like just to get your view. We have cited your letter.

Mr. COLVIN. I appreciate that very much, too.

Mr. STOKES. And you heard the response, right, of the agency. And is there anything further you could say with reference to this?

Mr. COLVIN. I don't think so, Mr. Chairman. I think at this point in time, as both the Administrator and General Pearson have reported to you, they have concurred in my recommendations and

they are tough decisions. They are very difficult decisions for them to make, I recognize that, but I also recognize that it is the Administrator's decision to make.

It is a programmatic decision. He and his staff are evaluating that decision. They are taking it under serious evaluation and I am assuming that once I get their response, that we will do our evaluation of that.

Mr. LEWIS. Mr. Chairman, if I might interpose there, what the Chairman is bringing you to, is the administrator's strong recommendation and suggestion that the Downey facility could save money by closure, $50 million a month; is that right?

Mr. GOLDIN. No.

Mr. LEWIS. A year?

Mr. COLVIN. Annually.

Mr. LEWIS. Or total?

Mr. COLVIN. No, annually.

Mr. LEWIS. All right, annually. He suggests that until the research is done that gives us an answer as to whether you have another pathway that is realistic, you ought to keep those bodies around. That would seem logical, but that wasn't a part of what you suggested.

Mr. COLVIN. No, that was not part of my suggestion. You know, that again, I think, Congressman, is a programmatic decision. I will not interject myself into a programmatic decision. What my mission here is and my role is to point out to the Administrator what his possibilities are. And then the program office does the evaluation on those. Now, once they have done that evaluation, they will respond back formally to my recommendations and then I will evaluate that for acceptance or ask them to go back and recheck it again or reevaluate it again.

Mr. GOLDIN. Congressman Lewis, I would like to clarify the NASA position. We are looking at how we could retain the capability for critical shuttle skills while at the same time closing Downey. We believe that the Inspector General has made a very valid set of observations to the Administrator and to the Associate Administrator.

So observation number one is our structural spares program was too robust, so General Pearson reacted to that by cutting down the level of the structural spares, and we owe an answer to the Committee to show exactly how much savings we will have relative to the numbers that Inspector General Colvin pointed out.

Secondly, we are taking a very hard look at consolidating activities on the Shuttle to see if there is a possibility of closing Downey, while still retaining those skills.

Mr. LEWIS. Those skills, okay.

Mr. GOLDIN. So we believe that the Inspector General has made two very valid suggestions for cost savings and we are looking at them and looking at it and taking both of them very seriously.

Mr. LEWIS. Thank you.

Mr. STOKES. All right. I think this is a good point for us to conclude for the day. And are we set for 9:00 or 10:00? All right. Tomorrow morning we will be back in H-143 over in the Capitol, and we start at 10 a.m.

So at this time, then, we are adjourned until 10 a.m. tomorrow morning.

THURSDAY, APRIL 29, 1993.

ADVANCED SOLID ROCKET MOTOR

Mr. STOKES. The committee will come to order.

This morning we would like to start with SF-1 through 10 and have some discussion on the Advanced Solid Rocket Motor (ASRM).

The request for 1994 for this activity is $280,400,000 and last year, because of budget constraints, the Congress reduced the funding profile for the program and directed that the initial first launch be delayed in February 1997 to December 1998; is that correct?

Mr. GOLDIN. Yes.

Mr. STOKES. Is that correct, Mr. Aldrich?

Mr. ALDRICH. I didn't hear the first part of your remark, I am sorry.

Mr. STOKES. Sure. Last year, because of budget constraints, Congress reduced the funding profile for the program and directed the initial first launch be delayed from February 1997 to December 1998.

Mr. ALDRICH. Yes, that is correct.

Mr. STOKES. That is correct. All right. However, in order to meet the December 1998 launch date, the request presented to the Congress was not sufficient and would require an additional $60 to $70 million; is that correct?

Mr. ALDRICH. Yes, that is correct.

Mr. STOKES. And I take it, it is also correct that this budget assumes a first flight of sometime in the year 2000; is that correct?

Mr. ALDRICH. Yes, the new budget that has been submitted now has a first launch in December of 2000.

Mr. STOKES. Let's review the bidding on ASRM. On March 31, 1987, Administrator Fletcher wrote then-Chairman of this Committee Ed Boland, a letter announcing the proposed acquisition of future space shuttle solid rocket motors. And in the letter, he mentioned and I quote that, "the potential to improve performance is a major factor as a result of the weight growth in the STS program, resulting from the STS 51-L Challenger recovery decisions."

Before the shuttle accident, the shuttle could carry 62,000 pounds to a 28 degree incline orbit using 109 percent engine thrust. Is that number essentially correct?

Mr. ALDRICH. That number is correct. However, we had never certified the 109 percent performance. We never arrived at the ability to do that but it was in the plan prior to the Challenger accident.

Mr. STOKES. After the accident. Let me ask you this, isn't it a fact that not only was it in the plan, but it was also scheduled on the next flight?

Mr. ALDRICH. I will have to go back and research that. I don't believe we were that committed to or close to 109 percent. I may be wrong.

Mr. STOKES. I am talking about Galileo.

Mr. ALDRICH. I will check on that.

[The information follows:]

SPACE SHUTTLE MAIN ENGINES

We were in the certification process for operation of the Space Shuttle Main Engines (SSMEs) at the 109 percent power level, prior to the Challenger accident, to support the Galileo mission. Discussions were underway prior to Challenger to re-evaluate the Galileo mission trajectory to eliminate the requirement for 109 percent power level, due to technical difficulties encountered in the certification process.

All missions since Challenger, including the Galileo, have flown at the 104 percent power level. Currently all SSME flight components are tested for at least 52 seconds at the 109 percent power level, and operation at this power level is permitted only in the event of an emergency.

Mr. STOKES. All right. After the accident, that same capability, the same orbit using 104 percent thrust has been reduced to what?

Mr. ALDRICH. The same capability after the accident, I believe, is about 32,000 pounds to that same orbit. I might ask General Pearson if that is the correct number.

Mr. STOKES. General?

General PEARSON. Which orbit, 28 degrees? It is 53,000 pounds, that is with no reserve.

Mr. STOKES. What is it?

General PEARSON. It is 53,000 pounds with no reserve.

Mr. STOKES. Will it be reduced further in the future owing to changes to the orbiter such as the advanced turbo pumps and so forth.

General PEARSON. Yes, by about 1,800 pounds if we put everything in is what we are looking at right now.

Mr. STOKES. Now, if the access to space study, which we just discussed should suggest that we fly the shuttle well into the next century, say 2010, then you believe that the current and further eroded shuttle lift capability is adequate?

General PEARSON. If we go to 57 degrees, it would be further eroded, of course. Did I get the question right?

Mr. STOKES. Same orbit.

General PEARSON. With all the improvements in, I have 52,300 pounds with no reserves.

Mr. STOKES. I guess in the access study, the question is, is this adequate for the future?

Mr. ALDRICH. In the Access to Space study, there are several options which, as we described yesterday, involve continued shuttle use anywhere from the year 2005 to up to perhaps 2030. And the changes we would be talking about for those options to the shuttle primarily deal with augmentation to crew safety and other changes that can help in further reducing operations costs. It is my understanding that the performance would be adequate for the known shuttle requirements. However, in the Space Station redesign effort that is currently going on, there are discussions of other orbits for the Space Station and other configurations.

And so it will not be completely clear just how supportive the current shuttle performance would be until we know what the new Station design will be and what the inclinations will be. The ASRM could be of great benefit to that, depending on the overall outcome of those studies.

General PEARSON. Sir, could I——

Mr. STOKES. Sure.

General PEARSON. If we go to the higher inclinations, of course, we lose payload capability on that. Down to about 38,000 pounds.

Mr. STOKES. Let's ask you this question, regardless of what option is chosen for redesigned space station or what orbit inclination station is launched, we are going to fly the shuttle for an additional 15-plus years.

Should we proceed with ASRM to restore much of that payload capacity?

Mr. ALDRICH. This budget recommends, and I recommend that we continue to plan on the ASRM at least to the point where we are certain that we know what our requirements are and what our inclinations are, and what our long-term view of the total shuttle requirements are. It is a prudent plan to increase the shuttle capability in all of the areas that were initially intended, and the program today still will achieve all of those objectives if we proceed down that path. I might like to defer to Mr. Goldin, though, if he would like to add anything about decisions on the ASRM and, as we go forward, how that would fit into the agency standing.

Mr. STOKES. Mr. Administrator?

Mr. GOLDIN. The present plan and budget, as submitted, calls for continuing the ASRM given the spectrum of requirements that we see. And until we see a change in the requirements, I think the ASRM will be there. But we have not yet completed all of our studies and we don't know all of the orbits and all of the inclinations. We are a ways off on that right now.

SAFETY AND OBSOLESCENCE UPGRADES

Mr. STOKES. Page SF-1 through 14, 1-14. The safety and obsolescence upgrades are detailed. NASA is requesting $140,200,000 for this activity in 1994. Our staff was briefed on the alternate turbo pump and it would appear that the liquid oxygen piece of that puzzle is coming around well.

But the question of spending additional dollars for these upgrades, particularly the advanced fuel pump and the large throat main combustion chamber carried on this page at $22 million, is somewhat connected to the issue of whether or not we are going to use the shuttle in an active fashion or let the flight rate erode.

I think it is fair to say that the position of the Committee has been that, since we are appropriating four-plus billion for the shuttle program, and since whether we fly the shuttle twice or eight or nine times, it will still cost roughly the same amount of money, we might as well fly it at least eight times a year.

I also think it is fair to say that there has been a great deal of pressure to continue to reduce the flight rate to six, or six to eight, and even four to six and so on. The advanced turbo pump program alone will cost a total of almost $1.1 billion. So it strikes us it is a great deal of money if we are not going to make use of the shuttle's capability.

So I would be interested in the shuttle manager's view of what we just said and, of course, the administrator's view also.

General PEARSON. I would agree with you all the way on that, Mr. Chairman. As of this point, we are scheduled into the outyears at eight flights and look forward to flying at that rate. The Administrator has always supported that rate of six to eight. Six is the absolute minimum to maintain the system safely, so we would never

want to go below six flights. We are working to keep up the eight flights.

Mr. GOLDIN. I would like to just establish why I asked for a minimum number of flights. I just wanted to be sure that we at NASA had a public and an open position about what it would take to assure the shuttle safety, because there have been a number of discussions that maybe we could go down to four flights over three flights or two flights.

My experience in industry said that, to keep the crew sharp, we needed a minimum number of flights and I wanted to establish a floor and that is where the number six comes from. That was based on a very thoughtful review by the people at Johnson Space Center, Marshall Space Flight Center, Kennedy Space Center, Stennis Space Center and Headquarters, so that is the reason for the six. six.

If you look at our budget, we have scheduled eight flights per year over the five-year plan. And we believe we will have full utilization of those flights.

SHUTTLE OPERATIONS

Mr. STOKES. Let's turn to page SF2–5. Under shuttle operations in the flight hardware activity on that page, the Solid Rocket Booster request for 1994 is $515,700,000 and of that amount, $387 million is direct payment to the prime contractor.

And if we divide eight shuttle flights per year, which is the current manifest into that amount, it would equate to a cost of $48,300,000 per flight for a set of shuttle solid rocket motors; is that correct?

Mr. ALLISON. That is correct.

Mr. STOKES. The marginal cost of a shuttle flight is roughly $44 million. The marginal cost is the cost of adding or subtracting one shuttle flight to the yearly manifest; is that correct?

Mr. ALLISON. That is correct.

Mr. STOKES. All right. Then the problem the committee is having is, how can the marginal cost be $44 million when it costs $48 million for just a set of solid rocket motors? Explain that for us.

General PEARSON. Could I——

Mr. GOLDIN. We have two volunteers.

Mr. STOKES. All right.

General PEARSON. My take on it is, we are just buying the solid rocket motors, but the marginal cost is the refurbishing cost between the flights.

Mr. ALLISON. The marginal cost is just what you would change if you added or subtracted one flight. It isn't the average cost, it is just the propellants, the things that you could actually reduce or increase to change the flight rate by one. It can't be the average cost. Everything has a minimum. You can't reduce an average when you reduce one flight. And that is the basic reason for the difference. You have a minimum base that you can't go below.

Mr. GOLDIN. Mr. Chairman, the Administrator would like to review this with his staff and come back with a statement on the record after we review it.

Mr. STOKES. Let me ask you this, and you might want to add this to it. This is a way to try to look at the question a little differently, and that is, are you telling us that regardless of how many times we flew the shuttle in a given year, whether it was one time or eight times, that the contractor would still bill us for $387 million?

Mr. ALLISON. No, sir. We are not saying that.

Mr. STOKES. You are not saying that. All right.

[The information follows:]

Shuttle Flight Cost

The average cost per flight is the average cost in a given year for a shuttle flight. It is derived by using the annual budget and dividing it by work in process or by the number of flights in the year. It includes the base cost of hardware, software, and facilities to operate the Space Shuttle on a sustained basis. The average FY 1994 cost per flight is $392 million.

The marginal cost is the cost associated with the addition or reduction of one flight from the shuttle manifest. It includes consumable, hardware and labor that can be removed with only temporary adjustments in the flight rate. The assumption is that all facilities and skills must be maintained to support the capability associated with safely flying the sustained flight rate. The Space Shuttle Program would not lay-off contractor employees during only temporary adjustments in the flight rate. The total Shuttle marginal cost for deleting a flight in FY 1994 is $40.1 million.

The average cost of a solid rocket motor flight set is $48.5 million in FY 1994. The marginal cost for a set of solid rocket motors is $7.1 million. Because of the program's long-term procurement strategy associated with solid rocket motor propellant and insulation material, no reductions in these materials are available in the budget horizon. In addition, the Solid Rocket Motor Project has lifetime fixed price buy contracts for most of the other material and subcontractors. Thus, 85 percent of the $115 million material and subcontract costs are essentially fixed in nature.

The same fixed cost dynamic applies to manufacturing labor. If the sustained flight rate experienced only a temporary adjustment, then the savings from a light reduction come from a minimal change in shifting and overtime assumptions, and no lay-offs would be assumed. The Solid Rocket Motor Project is able to reduce $4.5 million for a flight deletion out of the total $194 million of manufacturing labor budget. The supporting manpower to maintain the sustained capability is relatively fixed.

Identified below is the FY 1994 content of the average and marginal cost (which is included in the average cost) of the RSRM:

AVERAGE	MARGINAL	
$48.4M	$7.5M	
$23.4M	$4.5M	Motor Manufacturing Labor - manpower required for manufacture and refurbishment of solid rocket motors. This includes touch labor (marginal cost) and support labor (production control, manufacturing and industrial engineering, SR&QA, testing), and level of effort labor (procurement, safety, QA control, tooling sustenance).
$11.9M	$1.4M	Materials - propellants, insulation/liner rubber, nozzle ablatives including rayon.
$ 1.6M	$ .7M	Subcontracts and hardware - expendable hardware including O-rings and heaters, reusable hardware (new & refurbished) including case, nozzles, and stiffener rings,

		other subcontracts including vendor studies and purchase of piece parts.
$ .9M	$ .5M	Freight - shipping costs for flight hardware.
$ 8.2M		Sustaining Engineering/other labor - sustaining engineering required for program management, engineering assessment, materials & processes lab, reliability, contracts, and RSRM facilities.
$ 2.4M		Other Direct Costs - computer support for engineering, manufacturing, quality, and management; travel; replacement and maintenance of tooling; leases for refurbishment facility.

In conclusion, a high percentage of the average cost per flight is required to maintain the capability (i.e., facilities, equipment, workforce, etc.) for sustaining a given flight rate. In addition, there are considerations such as fixed-price contracts and long-lead efforts associated with manufacturing or planning which may affect marginal cost per flight. Marginal cost per flight should be considered on a case-by-case basis due to these factors. Average cost per flight cannot be used to adjust budget for temporary changes in the flight rate.

Mr. ALLISON. There would actually be a change of $7 million for the solid rocket motor.

General PEARSON. That is also a short-term assumption. If you take a lot of flights out, you could get more money out of it, but the question has always been, if you take one flight out of the manifest, how much are you going to make on that? And the answer is that marginal cost and the refurbishment. But naturally, if you come down to flight rates that we think are unsafe, you could buy fewer tanks and buy fewer of other things and you could cut it down more.

Mr. STOKES. Take the eight flights, are you reducing it by the $56 million?

General PEARSON. If you took eight flights.

Mr. STOKES. He said $7 million.

Mr. ALLISON. Reduce it by the entire amount.

Mr. STOKES. Reduce it by the entire amount?

Mr. ALLISON. If you took all of the flights out, you wouldn't have a program.

Mr. STOKES. I guess when we look at the period of time, the three years, and we didn't fly anything, we still paid high costs.

Mr. ALLISON. Yes, sir, but we intended to go back and fly. The marginal cost on the redesigned solid rocket boosters includes the attrition hardware and things that you would use, full recovery of the aircraft where they go find out the SRBs. And the labor that assembles the hardware. None of the project support, the overhead, the flight support or the transportation is included in there. That is the difference between the average cost and the marginal cost on that particular project.

Mr. ALLISON. I would assume if we cancelled the program, we would get rid of everything.

General PEARSON. Except for the launch systems that you have to have to launch the other system with. With any system, you still have those costs.

Mr. STOKES. The Administrator wants to say something.

Mr. GOLDIN. I would like to go back through this. I think what we have here is Gary is looking at the marginal costs for just taking one flight in or one out. As you start taking a larger number in or out, then you begin to have more than just this number, and I think that is where the confusion is coming from. So why don't we just take a look at this over a broader range of taking one flight in and one out and answer the question in a broader perspective.

Mr. ALLISON. There could be a step function there.

Mr. GOLDIN. I think that is where the confusion is rightfully coming from. So we will plot a curve of a number of units and marginal costs and put an explanation of where there are step functions in it. You can't just take it down five or six units—you can't go below six units because then you say you are not flying. We can give you the marginal cost for one and two, but if you go to the third unit, then you say we are not flying. And then you are in a standby or shutdown mode. It is our position that we cannot go below six flights a year.

LAUNCH SERVICES

Mr. STOKES. That will be fine. Provide it for the record. On page SF3-1, NASA is requesting $300,300,000 for expendable launch vehicles and upper stages in 1994. This is a jump of $120 million from the 1993 estimate.

The request for intermediate launch is $63,200,000. The justifications on SF3-3 indicate that the major funding required in 1994 for intermediate class ELVs is 2-AS in support of a solar and heliospheric observatory mission. Also included in that line item are funds for the first, TDRS-G in 1997.

What was the funding source for the solar and heliospheric observatory and what is the total cost of that mission and also give us its history.

Mr. ALLISON. The development and operations for Solar and Heliospheric Observatory (SOHO) are funded in Physics and Astronomy.

[The information follows:]

Redesign Solid Rocket Motor

The marginal cost of RSRM is $7.1 million as stated previously. It consists of touch labor for flight sets and materials (propellants). Also as explained above, were we to have a temporary adjustment in the flight rate to 6 flights in a given year the adjusted marginal cost would be $14.2 million.

As stated in the hearing, 6 flights is the minimum level that allow us to maintain the proficiency with the flight support teams and is therefore a required level to safely fly based on our judgement and analysis. There would be step functions that occur at lower sustained flight rates. The total RSRM savings for reducing the sustained yearly flight rate from eight to six would be in the range of $25-35 million. This would result from the reduction in both the hands-on and support labor and restructuring of materials contracts and subcontracts. Currently we do not have the data to identify where the specific step functions would occur at even lower flight rates. This would assume that we would plan to flu at a flight rate lower than 6 for a sustained period of time. As we have stated previously, this would be below what we consider the minimum safe level of 6 flights.

While the marginal cost appears low relative to the average cost, it should be kept in mind that we are already flying at a low flight rate. At our current flight rate the marginal cost is 14% of the average. We estimate at 12 flights per year, the average cost would drop significantly since the fixed cost would be spread over a much larger base. At that rate the marginal cost would be 22% of the average.

There is a large fixed base needed to sustain the flight capability. This fixed base is being aggressively reduced through the target reductions and efficiencies imposed on each of the Shuttle projects. Major reductions in the operating base are occurring from previous levels through these cost targets amounting to over 20% from FY 1992 to FY 1998 once escalation and other factors are taken into account.

Mr. STOKES. Is it a line item.

Mr. ALLISON. No, it is part of the COSTR project, the Collaborative Solar Terrestrial Research project. This is half of the ISTP program. The other half is the Global Geospace Sciences.

Mr. DIAZ. SOHO is the European spacecraft that we are providing instruments for and the instruments are funded under the——

Mr. STOKES. Would it be fair to say that the new TDRS-G launch could be technically accommodated on the shuttle?

Mr. GOLDIN. It technically could be accommodated on the Shuttle, but the Administrator, under the new rules after the Challenger accident has got to evaluate and establish the need for flying a vehicle that either does or does not need human interaction. And at the request and discussions with staff yesterday, NASA has taken on an action to make that evaluation and establish the need for expendable versus the utilization of the shuttle for the TDRS vehicle.

Mr. STOKES. Within the large ELV line which is carried at $82,300,000 in 1994, are there any funds for the advanced X-ray astrophysics facility launch requirements?

Mr. ALLISON. No, sir, there are none.

Mr. STOKES. Also the intermediate expendable launch line item is the subject of a potential RFP for a series of launch services; is that correct?

Mr. ALLISON. Yes, sir, I believe it is.

Mr. STOKES. What would be the total cost in real year dollars of the first launch vehicle under that RFP?

Mr. GOLDIN. Al?

Mr. DIAZ. That is a procurement sensitive piece of information, but it is measured in hundreds, to the $100 million range, something in that range.

Mr. STOKES. Is this the price if we buy one vehicle?

Mr. DIAZ. I think you might be able to fix on it if you looked at the SOHO vehicle. That is a procurement of one, and so that is what you might expect to pay for one vehicle.

Mr. STOKES. How much is the SOHO vehicle?

Mr. DIAZ. About $137 million.

TRACKING DATA AND RELAY SATELLITE

Mr. STOKES. Turning to the tracking budget on SF4-10, the tracking data and relay satellite TDRS-II has displayed. This program was not funded by Congress and was subsequently canceled, and this action was taken largely because of our 1993 budget problems and is illustrative of the fact that we simply have too much on the NASA plate.

However, it was suggested by the committee staff that NASA look at the possibilities of the stopgap measure of buying one additional TDRS vehicle within the current series if that could be procured from TRW for approximately $150 million.

The justification indicates that that effort was unsuccessful and our question is, was it unsuccessful because TRW could not commit to the costs that they had earlier suggested? Was it unsuccessful because of a possible protest to a sole-source buyer.

Mr. GOLDIN. Let me give the broad answer and then I will ask Charlie to give the details. NASA concurs with the Congress that it is not necessary to initiate the TDRS-II procurement. It is a very large procurement. We don't think that we have the requirements for the TDRS-II and in this budget we recommend not proceeding with TDRS-II. We intended to go out and procure a vehicle. We had a protest and Charlie can give you the details of that.

Mr. FORCE. We had three protests; the legal staff looked at the protests and felt they would be sustained and recommended that we go for a functional equivalent. The protest was along the line that NASA should go for a functional equivalent rather than a carbon copy of the original design and that is what we have proposed in this budget.

Mr. STOKES. The 1994 budget includes $48 million for kind of a son of TDRS-II concept and this would entail a fixed price contract involving three spacecraft. What is the total estimated cost of this program?

Mr. FORCE. Our estimate is slightly under $900 million. Again, we are hoping to be able to go out with an RFP fairly soon. As you suggested, we are looking at a fixed price approach and, therefore, we would have in a few months a firm price from industry to validate or invalidate.

SPACE STATION WORK PACKAGE IV

Mr. STOKES. I want to go back, now, to an area you touched upon briefly yesterday. And that is the situation with work package four space stations. And this issue is particularly important to me, since it involves NASA Lewis out in Cleveland.

I understand that the IG has issued this report and that there are differences in opinion between station personnel and the IG. So I would like to hear both Mr. Colvin's and your views on this matter. I would like to ask for the record.

Mr. GOLDIN. Sure, Mr. Chairman, let me say, first, that the memo issued by Mr. Colvin was a preliminary report and the NASA practice calls for the IG to issue a preliminary report, and before he issues a final report, that the IG give all the NASA team members that are impacted by the report a chance to respond.

After all the inputs are in, the IG then has a draft final report, which the Administrator then reviews. I had not seen the response to the preliminary report until this morning when it was called to my attention yesterday.

I have read it and I think it was a little misleading, if you looked at the front end of it, saying that the impacted group out at Reston hadn't had a chance to respond to the preliminary report. Well that was the whole purpose of the preliminary report. The preliminary report was very clear. That was done in a relatively short period of time and was looking for validation.

So I wouldn't construe that report as anything other than an internal NASA document, that the IG was seeking clarifications on a number of points where the IG felt that there may have been an absence of data or there may have been inaccurate data. And I think the response was a little overly forceful in the introductory section.

However, as I read through the report, the report concurred with every one of the IG's recommendations at the back end and recognized that there are a number of issues that must be worked. So I would recommend that the process be allowed to proceed and that we in NASA work clarifications of all the issues and I stand firmly behind the IG.

Mr. STOKES. Would it be fair to say that, at a minimum, you are concerned with what actually defined a CDR and is 90 percent of working drawings or what?

Mr. GOLDIN. Yes. That was one of the concerns that I think was a valid issue raised by the IG. In fact, I have asked the independent assessment team to take a look at the impact of the definition of the CDR and they have been having discussions at a number of NASA centers collecting the data. I do not have that data, so it is very difficult for me to respond and to say whether it is good or bad. I am not sure whether it is bad, it just may be a statement of where they are. The independent assessment team was asked to put that into perspective. So, again, I want to emphasize this was a preliminary report.

I don't believe it reflects badly on the NASA employees. I don't believe it reflects badly on the Space Station program. It is just the IG is meeting his responsibility to try and understand how we are performing in different areas and how we could do our job better. And we will respond to it.

Mr. STOKES. All right. We will probably want to just continue monitoring it with you. Mr. Lewis?

NATIONAL LAUNCH SYSTEM

Mr. LEWIS. Thank you, Mr. Chairman.

Mr. Goldin, welcome one more day. How many more do we have to go?

Mr. GOLDIN. This is it, at least for now, unless you want more meetings.

Mr. LEWIS. I am looking forward to that June meeting. It really is interesting to recall the roller coaster ride we have been on with various NASA programs, especially the shuttle program. I am remembering the positive response when we collected an errant satellite with the shuttle.

But now, with the long anticipated deferral and elimination of the national launch system, do we have a launch vehicle program capable of delivering payloads that is as flexible as shuttle? Do we have such a program on board anywhere in our process that would have a proven capability that shuttle has even though we have had highs and lows between now and the year 2000?

Mr. GOLDIN. Let me say something about the problem with the shuttle, our Access to Space for humans and other cargo for the United States of America. I also want to point out that, in spite of all the ups and downs on the Shuttle, it is the only machine of its type in the world. I have met with the Russians and they have told me that they don't have a machine that has a down cargo capability that the shuttle has.

Mr. LEWIS. That is part of my question as well, whether anybody else has anything out there.

Mr. GOLDIN. This is the only machine. I have to tell you, as the NASA Administrator, it is just amazing to me the process that we lived through. I lived through that satellite rescue. I am proud of the astronauts that took on a tough job. And every day we have thousands of NASA employees working on the Shuttle. And it is as though it is like the stock market. The national mood on the shuttle swings with very small nuances.

I am very, very concerned about the fact that NASA has been asked to manage the safety, which is exactly what we are doing. And I pointed that out in my opening testimony yesterday. I am proud of the people down at the Cape, because we have safety systems that work. Our objective is not to satisfy the press and launch the shuttle to meet a launch moment or a launch date so we can have nice press, our objective is to make that machine as safe as possible so that when those astronauts climb into it, they have confidence. So we are not going to respond.

And I want to tell you, I have called down the Cape every time. I have called General Pearson before each launch and I have said, you don't listen to the press. You do what is right because, in the end, we can't have it both ways. We can't drive to schedule and assure safety.

I am very proud of the shuttle and I am proud of the people that work on the Shuttle. It is a national asset and, yes, it has problems, but it is one of the most complicated machines ever built by humankind. The problem we have with the Shuttle is people like to think of it as an airplane, which has millions of hours and thousands of units.

But let me tell you about airplanes. We did a study at Kennedy Space Center on the on-time takeoffs of planes. It is 75 percent. Over the lifetime of the Shuttle, it is close to 50 percent. So, again, I want to put things into perspective. These are very wonderful people undertaking a very hard job. And on top of that, we have asked them to reduce their cost of doing business and improve the safety.

So this is a national asset and NASA is not going to react to the ups and downs in the press. And yes, we could have some problems, and yes, we could have another serious problem. But when was it that America was ever afraid of that?

Mr. LEWIS. I not only have empathy for, but agree with the view that you are expressing. I nonetheless find myself riding the roller coaster. The Hubble experience was one of those highs. And then at the same time, you have to ask yourself—why do you think that the Shuttle has so constantly been bashed?

Mr. GOLDIN. The problem we have is the shuttle started out as an outstanding program. But as cost pressures developed, we have not had the flexibility to look at total life cycle costs to design those things into the system, that over the 20, 30-year life cycle of the Shuttle would allow us to have a much smoother operation and a lower cost operation. The design engineers didn't have that flexibility. And it became part of the process where we would manage to cost and just manage the development costs. And that is why I am careful not to say that anyone did anything wrong. That is what the Nation decided to do, but now we have the problem.

We don't have the flexibility of going back and designing the Shuttle for operability. We are trying to do the best we can. I think that is where the root cause of the claim is. At the time, there was difficult budget decisions, and I don't want to say that the people that made the budget decisions did the wrong thing, but one of the things that we have emphasized is that we want to take a look at life cycle costs and give those wonderful engineers an opportunity to make sure that the new programs we start look at the total life cycle. I think that is the genesis of it.

But right now, if we want to start replacing the Shuttle today, we couldn't do it in less than 10 years. So the decision we have to make is, as a Nation, are we going to stand behind the people that operate the shuttle and recognize the difficulty that they have, or are we going to stop flying it? I don't think we can have it both ways.

In the meantime, it is very important that we as a Nation decide what our long-term strategy is. We at NASA want to work with the DOD and the Congress and the Department of Transportation to help conceive a program that perhaps in the future could phase in so we don't have this problem. But as the Administrator, I am going to be the lightning rod. I am not going to allow the NASA employees to be bashed over a situation over which they have no control. I know it sounds like strong language, but these are hard working, good people. And it is not a pretty picture. We are going to have to live with this for a decade and I seek the support and understanding of everyone involved. I don't know how to say it any simpler.

Mr. LEWIS. I have only one general question. Given what we know about the agency's multiyear plans for upgrades and improvements, you must have discussions in-house about the odds of another accident like Challenger.

Clearly the price we paid is painful as well as educational. What are you saying about the prospects of another Challenger?

Mr. GOLDIN. Let me put it on a personal level and then I will put it on a corporate level for NASA. When I was in industry, I designed and built probably more spacecraft than anyone in this country. I designed and built military and NASA spacecraft, and when I went to a launch, I waited until they dropped our spacecraft out of the Shuttle. Then I would start puckering up. I want to tell you, with each and every launch, it is a gripping experience for me on a personal level. I speak to the astronauts before the Shuttle takes off. I know each one personally because I want to make sure I know it is a human being because I know the risk involved. And I talk to him after the launch because it is important to the administrator to know the trust that they have in me to make the right decisions. So it is gripping, and I know that with each launch, there is a possibility that we could lose that Shuttle, lose those astronauts. But the choice I say is: Do we make a commitment to fly?

We are on the cutting edge. This is not an operational machine, it is an experimental machine and we are doing things that no other Nation in the world could do. So we have to decide as a Nation, do we have the integrity, the intestinal fortitude to not lose our Nation psyche for a decade if we lose another Shuttle.

Again, I submit, America has to be ready to stand up to this. When we were breaking the sound barrier out in your district, we were pushing the limits. And occasionally we lost a pilot. But let me tell you, those astronauts understand what they are undertaking every time they get into the Shuttle.

And I want to say this openly so it is on the record. We could have another loss, but America has to decide, are we going to become introspective and walk away from the edge or are we going to be bold? And if we are bold, sometimes we do take risk. But I want to tell you, it will not be because of incompetence. This is a complicated machine and we are doing things that can't be done by anyone else in the world. I don't know anything else I could say.

Mr. LEWIS. Mr. Chairman, that was a very important and poignant response. It is very, very important that we have thought this through carefully, individually as well as collectively.

Thank you, Mr. Chairman.

SPACE SHUTTLE ADVANCED CAPABILITIES

Mr. STOKES. Mr. DeLay.

Mr. DELAY. I have no questions.

Mr. STOKES. Mr. Gallo.

Mr. GALLO. Thank you, Mr. Chairman.

Just following up on that, from a personal observation, I think there have been so many successes with the shuttle. I recall the first one that went up and everyone was glued to the TV. Each progression of shuttle launches thereafter became almost a matter of fact.

However, I think when the Challenger had its problem, that is when it hit home that each one of these launches involve risks. I think that your questions are poignant and the response was certainly eloquent.

Dealing with the space shuttle, there have been those that have said that the shuttle itself should be flown as little as possible. And then there are others that say the Shuttle should be replaced as soon as possible. This seems impractical to me, given the investment we have made in developing this unique national asset.

Given your emphasis that in the future programs we should focus on advanced capabilities of existing technologies, what is your opinion on these differing views?

Mr. GOLDIN. I believe that what we ought to do is undertake a prudent program to not just have new draft engineering, but to have NASA and the DOD spend money up front to investigate a variety of possibilities for upgrading the Shuttle, and looking at alternate approaches. We ought to have a reference point.

And part of the challenge I have laid on Arnie Aldrich, I have said, is to get the shuttle cost to come down by a factor of two over the 1992 baseline and increase its reliability by an order of magnitude. That is our reference point to see what we can do with the Shuttle. Then, I've asked Arnie to show me new systems and show me how close those new systems come to beating that objective.

Coming out of industry, I believe that competition is the strength of America. And I think that it will sharpen the tools of the con-

tractors working on the Shuttle to know that others are shooting at the target. And I think that in the end, America will benefit.

So in this package that we have proposed, we are looking at a program where we put a pause in for a couple of years and say, let's do it prudently. Let's stop. Let's see what other opportunities exist rather than saying we are going to throw the Shuttle away and we have no reference point, we are going to go and continue running.

I have talked to the contractors and I have been out to their plants. They have a lot of ideas. Let's put the rubber to the road and see what they can do.

SHUTTLE FLIGHT RATE

Mr. GALLO. What would you save if you cut the shuttle flights?

Mr. GOLDIN. Well, we can't cut below six flights per year. This is the fundamental issue that I asked General Pearson to review. It is our observation that from a safety standpoint, the alertness of the crew, the training, the reliability numbers say that we have one in X chance of failure for the Shuttle.

But there is a set of statistics called Bayesian statistics that say, if you constantly upgrade as you go along, you make a significant improvement in that reliability. And the key to the Shuttle's safety is not in the reliability numbers, it is in those thousands of human beings who every day make decisions that establishes where we are.

Keeping the morale of this group up and keeping them focused and trained is a real key to shuttle safety. So we will continue to do that, but we cannot go below six flights. And it will be this Administrator's recommendation that, if we wanted to save money and go below six flights, I would say stop flying the Shuttle. We must have six flights a year.

SHUTTLE SUBSTITUTE

Mr. GALLO. Is the space booster vehicle proposed by the August report a substitute for the shuttle?

Mr. GOLDIN. In and of itself, it is not a substitute because the Spacelifter would only be a heavy lift vehicle that would take payloads into space. If the Nation were to go with the Spacelifter, NASA would have to develop a vehicle to go on top of that spacelifter that could carry astronauts, and there are a couple of approaches to that.

One is called HL20. That would be a $5 billion development on top of the cost of the Spacelifter. And the other approach is to use an Apollo-like command module. Again, this would only carry astronauts. Then we would have to develop another vehicle to develop up-cargo capability and a third vehicle to develop down-cargo capability.

So that is why we want to be very clear and we don't want to come to the Congress one step at a time and say, we went ahead with the Spacelifter, two years later we come back and say give us $5 million for HL20, and then we come back and say we forgot. We need an up-cargo vehicle. And then Congress gets upset with NASA. That is why I say, let's make an investment in upgrading

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the Shuttle and then run a competition with the new vehicle. And spend the time that is necessary, but then when we proceed, let's have life cycle costs worked out and retire the risk and proceed with a program that everyone understands and involve the Congress in the process.

Mr. GALLO. Is it your plan for the shuttle to continue until the year 2025?

Mr. GOLDIN. I believe that for prudent planning, for NASA to do anything less than saying, 2005 would be a disservice to the country. And the question is: Is it 2005 or 2030? But I think we ought to take a three to five-year period, do what is necessary, perform all the tasks, and make a decision and move forward.

There may be pressures for a lower cost commercial launch vehicle and maybe that decision will have to be made sooner. But in terms of NASA's involvement, I emphasize it is not just the Spacelifter, it is all the other aspects that go with it. The folks down at JSC are taking a look at the possibilities but we want to price it out right.

SHUTTLE FLIGHT RATE

Mr. LEWIS. Do you think we ought to be cautious if we move the number of flights below eight or nine a year, just because, as you reduce those numbers, you increase significantly the cost for launch, even at six?

Mr. GOLDIN. Right now, I don't see any reason to go below that amount. Six is a reference point for safety. In fact, during one of the discussions we had yesterday, staff said, NASA baselined the AXAF vehicle to go on the Shuttle. There is a reason for that. This is a national treasure. This is one of the great observatories. Just think about the possibility if we were to put the AXAF vehicle on an expendable launch vehicle and then it got to orbit and we had a problem. You could never bring it back.

Mr. LEWIS. Even with all the lessons we have learned and the money we have spent, the program could be in jeopardy if the cost per launch goes up. I think you ought to be drawing the line not at six, but eight.

Mr. GOLDIN. You are saying eight from an economic standpoint. Okay, I will take that under advisement, but all I can say, if you look at our plan, we have eight launches per year and we believe that is going to be necessary to meet all the objectives that we have. So I think we meet the intent of what you are saying and I understand what you are saying.

SHUTTLE UPGRADES

Mr. GALLO. It would seem, then, that if the 2005, if, in fact you are going as you indicated in some of the questions earlier to Representative Lewis, about continuing the technology as technology is available that would replace some things on the shuttle, so that it would be a constant updating, so the likelihood is that you might get more years out of it than 2005 as you said.

Mr. GOLDIN. I feel strongly about the upgrades that we have recommended. I feel it is essential to have the oxidizer and fuel alternate turbo pump, the new powerhead and large throat engine.

These are fundamental to improving the safety of that Shuttle. These large throat engines will reduce the chamber pressure by 9 percent. This business of 109 percent performance, as an engineer, I never understood a margin that went above 100 percent. It is Newspeak from "1984."

Our objective is to make this safer; the alternate turbo pump allows us to have welds that we can see. It allows us to have a much higher reliability. Nine of the top 20 safety problems associated with the shuttle engines are in those turbo pumps. We are putting in modern avionics. Our Shuttle is using avionics from the 1960s. Is it a wonder that we have a problem when we go down to the Cape? We shouldn't be surprised. We are beginning to approach the state-of-the-art for the general aviation industry which is 30 to 40 years old and here is one of the most incredible machines. So as we go forward, NASA is going to invest in the Shuttle because we can't ask the astronauts to get into that machine and have it to fly to the year 2005 or later so we are going to continue.

SHUTTLE ORBIT TIME

Mr. GALLO. What plans does NASA have to expand the operation of the shuttle. And I say, for instance, efforts to keep it in orbit for longer periods of time?

Mr. GOLDIN. In our plan here that we have submitted, we are looking at an orbit that could operate up to 30 days and perhaps even 90 days. We believe that this is essential to do missions with the Russians.

In this plan we are talking about sending the shuttle up to the Mir space station for multiple missions between now and the time we have our space station on orbit. The purpose of this is to start getting back science now and not having to wait and to test out concepts for the space station in space to take risks out of the program. So we believe it is going to be a minimum 30-day orbiter capability and perhaps 90 days.

SHUTTLE ROLE/REDESIGN OF SPACE STATION

Mr. GALLO. You see the shuttle playing an important role, even with the redesign of the space station both in the area of how it is utilized once the space station becomes operational?

Mr. GOLDIN. Let me tell you again, it may have warts and blemishes, but it is our only machine. And the shuttle is absolutely crucial to the deployment of the space station. We have no other asset.

The Europeans are talking about bringing some other assets on line at the turn of the century, but it isn't a hard program yet. The Russians have some capability that is very limited. You know, they have the Soyuz and the Progress. But we were worried about this 53,000 pounds. We are talking about, you know, things that are on the order of magnitude less capability than that.

So, again, I want to put it into perspective. This is a unique machine and again, I say, we could say that it has a lot of problems, but there is nothing else like it in the world and we are going to have to make it a better machine because we are going to be using this machine for at least a decade or more.

Mr. GALLO. Thank you.

Thank you, Mr. Chairman.

SHUTTLE OPERATIONS

Mr. LEWIS. I agree with everything that you have been saying. There is no doubt that, with the upgrades, it is a fantastic vehicle that we can use well into the beginning of the next century. As we make those investments, though, you have to fly it. And for political reasons you shouldn't be cutting back the numbers. We end up eroding the base of support around here. That is so important.

Could you repeat the charge you gave to Aldrich about the shuttle and the investment we made and its capability, competition.

Mr. GOLDIN. Oh, I will be happy to repeat it because this is my charge and I know what I told him. I want competition. And I feel it is necessary to establish a reference point as an objective. So as the objective for the next launch machine that NASA is going to undertake, the Shuttle is a candidate and new concepts are candidates. I asked Mr. Aldrich to see if it is possible to reduce the cost of shuttle operations by a factor of two over the 1992 baseline and improve its reliability by an order of magnitude. That is what I am asking him to do and I am asking the industry to come back and give us other alternate concepts that can beat that, equal or beat that, and let's have a race.

Mr. LEWIS. We are not going to throw the baby out.

Mr. GOLDIN. Not until we see something better.

Mr. LEWIS. It reminds me of a conversation that I had yesterday evening on another subject with George Brown, Congressman from California, about the space station.

Mr. GOLDIN. Could you be more definitive, sir?

Mr. LEWIS. He was talking about that fourth option besides ABC. He wasn't so convinced that B was the best option. And I thought the way you expressed yourself earlier said, we have something that we put a lot of money into and it looks like it is working. For political reasons, we shouldn't be changing this.

Let's sell it in the marketplace, all the way to Pennsylvania Avenue.

Mr. GOLDIN. Well, I hear what you say. I must tell you, as an Administrator of NASA, I am committed to carrying out the President's directive. I am committed to assuring that NASA is an honest broker in the process and brings all the data to the table. That we don't bring any data to the table that will mislead or misrepresent capabilities and that we ferret out the root cause of why we are where we are. And we will have that data.

It is a short time. But I looked back in the records to see what my predecessors had done. And I looked at the Mercury program. We had never flown a human in space. From the day the program was authorized, it took three months to get the contract going. It took nine months to build the first article, and 22 months before Alan Shepard was in place.

I think our President wants us to get back to where we were and we want to get back to the future. And that is really what he has challenged us to do. I would really like to invite you to come over to Crystal City and meet the new NASA and see the faces over in Crystal City and see the brilliance we have over there. I think it

will give you a confidence that we are moving forward and that we have outstanding work going on.

And I know, sometimes I am even subject to that myself, you know, when I am here. But these folks are dead serious about meeting the objectives and we are going to see how close we can come. And I know it is a stretch. I know it is tough. But we want to get back to three months from authorization to let a contract, nine months later have a unit and 22 months later have a human in orbit. That is where we ought to be.

Mr. LEWIS. Our chairman has shown a willingness to travel and take a look and have contact. We're learning by doing.

Mr. STOKES. I will even go with you. How is that?

Mr. GOLDIN. We would love to have you, Mr. Lewis. I would like to express my appreciation to you for asking me a difficult question. That question you asked me was long overdue and I am pleased a Member of Congress asked that question. It is very important.

EXTENDED DURATION ORBITER

Mr. STOKES. You know, as you were replying to Mr. Gallo's question about extended duration orbiter, I really was struck by the fact that this same committee seven years ago recommended to NASA the extended duration orbiter and we were hotly opposed at that time about it. And I just think it is interesting to see that you have come full cycle.

Mr. GOLDIN. This administrator listens to the committee.

PRESIDENT'S COMMITTAL TO THE SPACE STATION

Mr. STOKES. We have that on the record.

Let me ask you, I guess there is another critical question in my mind as we discuss this whole space station thing and I have thought about it and thought about it and that is, whether you believe that the President is fully committed to the space station redesign effort and whether you believe that he is fully committed to supporting this is choice in that direction?

Mr. GOLDIN. I want to tell you that I believe the President is deeply committed to the Space Station. And more importantly, he and the White House staff have set up what I consider to be an exceptionally innovative and outstanding process for the redesign of the Space Station.

I emphasize the word "process" because that is what we are undertaking. The NASA of the past would have been asked to redesign the Space Station, come up with a single point solution, present it to the Congress without peer review. What we have here is a process where NASA has been asked to come up with three approaches and to make all three approaches work. And I might say that the President did listen to the Congress and the Congress made their views known on what one of the configurations might be and we are incorporating that. But this process is an open process and it is an engaging process and the peer review involves some of the top scientific and business and engineering minds in the country. It is an open process where all of America can watch what is going on. And it isn't just one final step.

But we have now had three meetings with this team. So when we get done, the President and the Congress will have this peer review data upon which to make judgment and not just have to accept NASA's single point solution. And I salute the President for having the courage to set up a very difficult process but a very strong process that I believe is going to get us on track.

And as the results are coming out, you know, this is Washington and it is inside the Beltway, and inside the Beltway, rumors start, and I want to give you my response to those rumors—Rumors about the President's commitment, rumors about what is happening. I view the rumors as an outstanding signal we have some outstanding results because. If we didn't have good results, rumors wouldn't be starting. So I salute the President's courage and I think President Clinton has done this Nation a service by stepping up to this. That is my position.

CONSTRUCTION OF FACILITIES

Mr. STOKES. We appreciate that, and needless to say, we are anxiously awaiting whatever comes out of the White House so that we can then know the direction which the President wants to go.

We will now move to the next area, which is NASA construction of facilities. NASA is requesting $545,300,000 in fiscal year 1994 for construction of facilities. That compares with $525 million in 1993. On page SUM-6, the justifications indicate that under the Space Station Freedom facilities line item, you are carrying 12 million in fiscal year 1993 for construction of the space station processing facility at Kennedy Space Center.

Last year, the amount required to complete that facility was carried at $24 million. Are you suggesting that you were able to complete the space station processing facility in 1993 for roughly half of the original estimate?

General MCGARVEY. No, Mr. Chairman. Last year, with the number of Congressional adds to the FY 1993 program, we were $34 million short of being able to accommodate all of the projects in 1993. In the process, we took some prior year authorizations that had not been fully funded and added those to the space station facility.

In that process, we reduced it by $12 million using prior years' authorization and using projects that had been canceled. As an example, the liquid hydrogen structural test facility was $8.8 million. We used that, going back then and applying the $8.8 million to the 1991 station authorization. And we had $3.2 million on the project from electric substation residuals at JSC which were savings and we applied that to the 1991 authorization and that made the $12 million reduction in FY 1993 that you see.

The total cost is still $72 million for the facility. And just in order to make room in the 1993 program, we used projects cancellations and savings.

Mr. STOKES. So last year it was still $24 million?

General MCGARVEY. That is correct.

Mr. STOKES. What is the total outstanding cost roughly in terms of facilities to complete all requirements for the existing space station.

General McGarvey. For the Space Station facilities through 1993, we have budgeted and allocated $146 million at this point. And if we are to build all of the facilities currently identified, it is roughly $300 million total carried out through 1999.

Mr. Stokes. Are you talking about $300 total or extra?

General McGarvey. $300 million total.

Mr. Stokes. Now we note there is no request for space station freedom facilities in 1994. Is that because of the current redesign under way or was it simply a matter of budget priorities?

General McGarvey. We originally had $27.2 million for three facilities in our budget request to OMB, and those reductions were made in the OMB mark in view of the redesign activities. And some of these may not be needed or may be needed later in the program.

Mr. Allison. Mr. Chairman, any facilities in the future for the Station would have to be covered in the Space Station and Technology Investment Package.

SPACE FLIGHT FACILITIES

Mr. Stokes. On page SUM-6, you list a total of 13 projects under the space flight facilities activity that initiate construction in 1994 exclusive of the ASRM request of $32,600,000. Of those 13 projects, do you require second year funding or is full funding for the projects contained in the 1994 request?

General McGarvey. All thirteen are fully funded.

Mr. Stokes. Relative to the continued construction of the advanced solid rocket motor program facilities, you are requesting $32,600,000 in 1994. Was that the requirement from the program office at Marshall or were additional funds required in 1994 to meet the current December 1998 first launch date?

General McGarvey. The $32.6 million is required to meet the total ASRM program, whether the launch date is in 1998 or the year 2000. But that $32.6 million is required, and there is a smaller increment that will be required in 1995 to build out the requirements.

Mr. Stokes. What is required to complete the ASRM facilities at all locations?

General McGarvey. In all locations—let me clarify for you. In straight construction, it is $411.3 million total cost. And as you will note in the past and in two years, we have had facility peculiar equipment funded in the construction appropriations. If you add that equipment to it, then the total cost is $574.3 million. There is $50 million in 1992 for special equipment and there is $113 million in 1993 for special equipment.

Mr. Stokes. That is what we need for our record is how much will you need in 1995 to complete the $411.

General McGarvey. We will only need $28.2 million.

NATIONAL AERONAUTICS FACILITY

Mr. Stokes. On page SUM-8, the table reflects the major new request of $181 million to upgrade national aeronautics facilities. Is it correct that this effort was begun last year with the $25 million added by the committee and the Congress?

General McGarvey. Yes, sir. Last year it was $25 million for high-speed civil transport and this year is a continuation of $181 million for the upgrade of existing facilities and direct support of the National Facility Study which will identify needs for new facilities to make the U.S. more competitive in the aeronautics industry.

UPGRADE PROGRAM

Mr. Stokes. What is the total run-out cost of the projects noted on page CF9A-1 under the upgrade program? Or is it that the $181 million requested——

General McGarvey. There is $181 million requested in the 1994 program. Until the studies, requirements, preliminary designs and other activities are completed, we will not know what the total cost is. I could ask Dr. Harris.

Dr. Harris. The two wind tunnels will probably come at $2 billion for both tunnels and will require five years to build those facilities.

Mr. Stokes. So we are talking about $181 plus about 2 billion?

Dr. Harris. Yes. The $2 billion is an estimate for two new wind tunnels which preliminary results from our ongoing National Facility Study indicate may be needed. The $181 million in FY 1994 will be used for a variety of upgrades and modifications to existing facilities as well as for studies of future facility requirements and preliminary designs for new facilities as identified in the ongoing National Facility Study.

Mr. Stokes. Are there any projects currently under construction that are experiencing overruns exceeding 5 percent?

General McGarvey. No, sir, I don't believe there are. I would like to recheck the numbers. We have a large number of projects under construction. To my knowledge, I don't believe there are. But I would like to furnish it for the record and take the time to recheck this.

Mr. Stokes. In the event that in furnishing it for the record you do find that there are any, we would appreciate being provided all the details relative to it that exceed 5 percent.

General McGarvey. All right, sir.

[The information follows:]

put in there. It is extremely efficient and requires very little maintenance and operator attention.

Mr. LEWIS. Mr. Chairman, it is an eerie experience to go out there. You are out in the real country and so you see these things out on the horizon. You are standing underneath them. A lot of the work that you are about is a wonderment, I must say.

Mr. FORCE. It is close to a football field in length. It is an extremely impressive device. You can't appreciate it. You really have to be there to appreciate the size of it.

Mr. GOLDIN. But also talk about the tolerance that you build that structure to across that football field size.

Mr. FORCE. It is like 5 millimeters mean square deviation.

Mr. GOLDIN. Across a football field. That gives you a sense and that is what the Russians don't have.

Mr. LEWIS. Did you experience any problems with the upgrades in Canberra or Madrid.

Mr. FORCE. To date we haven't. No, sir.

Mr. LEWIS. It looks like design installation of the antennae here in the U.S. is going to cost somewhere between a million and $2 million more than either of the foreign locations. What are the drivers behind those cost differences?

Mr. FORCE. Primarily U.S. labor.

Mr. LEWIS. I suppose just transporting it out there has something to do with the costs. By the way, we usually have an amendment on the Floor that addresses eliminating the search for extraterrestrial intelligence. I hope you can help us refine our communication It is much more than just that.

Mr. FORCE. These antennas are used in gaps from what we are getting from other satellites in a lot of the searches and activities of that nature. It is kind of a no-cost addition to our program.

Mr. GOLDIN. I might point out that as part of the TOPS program, there is some very fundamental signal processing technology that a number of people have told me is available, just into the commercial economy. So we just shouldn't look upon this as being something frivolous. It is a very prudent program, but we are trying to make it relevant.

Mr. LEWIS. I would be interested in exploring that at another time; the question of commercialization and what avenues we might be looking at.

Thank you, Mr. Chairman.

PROJECT CORE

Mr. STOKES. We turn now to research and program management. NASA is requesting a total of $1,675,000,000 for the research and management account, which is an increase of $60 million over the current 1993 appropriation. Because of the tightness of the committee's 1993 allocation, we were forced to cut the R&PM budget from a request of $1,660,000,000 to $1,615,000,000. That reduction was softened by applying $26 million of that reduction or 60 percent to Project CORE, which was an effort that the agency had under way to convert contractor jobs to civil service jobs.

The original goal was to convert almost 5,000 contractor jobs to civil service jobs and that effort was justified to the committees on

Construction of Facility Projects

There are currently 75 discrete facility projects under construction at a total estimated cost of $821.1 million. Only two of these projects have experienced increases in cost that exceed 5 percent. The two projects are:

FY 1991 Refurbishment of the 25-foot Space Simulator at Jet Propulsion Laboratory.

- Authorization: $13.2 million

- Current Cost Estimate: $15.8 million

- Percent Increase: 19.7 percent
  A formal report on the circumstances that resulted in the unusual cost variation was forwarded to the Congressional Committees on February 19, 1991, by the NASA Administrator. The principal reason for the cost increase is the high technical risks associated with the complex electro-nickel plating of the large 23-foot diameter optical mirror.

FY 1991 Rehabilitation of the Mission Control Center Power and Controls at Johnson Space Center.

- Authorization: $8.5 million

- Current Cost Estimate: $9.3 million

- Percent Increase: 9.6 percent
  The increase was the result of underestimating the complexity of the rehabilitation requirements of the power and control systems and the cost impacts due to limited access periods to the building during on-going shuttle flights.

In the CoF minor program category (repair, rehabilitation and modification, and minor construction projects less than one million dollars each), there are 172 projects currently under construction. These projects have a total estimated cost of $100.9 million. These minor projects are being accomplished within the amounts authorized for each category.

Mr. STOKES. Mr. Lewis.

Mr. LEWIS. I have just one. Mr. Goldin, when I learned that I was going to have the opportunity to come back to this committee with this responsibility, I decided to take a trip that I have put off for a very long, long time. You can drop four eastern states in my district easily. It is a long trip out to the National Training Center for the Army, but on the northern side of that is a fascinating location that I hadn't visited before known as Goldstone.

To go out there and see those antennae and have firsthand discussion about those programs takes you to the edge of another piece of the work that NASA is about. So I was very interested to note that NASA's 1994 request involves construction of facilities that include $17.6 million for construction of a 31-meter high efficiency beam wave guide antenna at Goldstone.

I think it would be helpful if you could explain the capability an antenna like this gives to the Deep Space Network and in what sense the first subnet of antennas may be obsolete.

Mr. GOLDIN. This is part of an upgrade program. Let me give you a broad perspective. The waveguide antenna is real modern technology. It is the type of thing that, by putting in that antenna, we build the tech base of the country. So we are not just putting an antenna into Goldstone, we are going to have some wonderful technology that comes out of it. So this is a cutting edge technology project. I would also like you to keep that in mind. With that, I would turn it over to Charlie.

Mr. FORCE. I think I would simply make a point that the United States has a world class facility in the Deep Space Network (DSN) that is completely unequalled otherwise. An example is that, even though the then-Soviet Union has two 70 meter antennas, and as you saw at Goldstone—we have three, one at Goldstone—when the Russian spacecraft visited Halley's comet, the Soviets came to us and asked us to do the tracking for them and we did so. Again, my point is that nobody in the world has facilities equal to the DSN. They are an essential and enabling part of all the planetary programs.

Today we are operating four spacecraft in the outer solar system. One of them is so far out that it takes radio signals, at the speed of light, eight hours to reach it. The transmitter on that only has the power of a light bulb in a refrigerator, and yet we receive telemetry data from the boundaries of the heliopause or the boundary that surrounds the solar system.

The 34-meter antennas are an upgrade. We originally constructed three 26-meter antennas in the Deep Space Network 30 years ago. One of those you saw at Goldstone. These are quite inefficient at the frequencies we are operating today to get the data rates back that we need. So that one was literally welded and expanded to 34 meters but it is increasingly deficient for the job that we have to do.

So we began a program to replace the old antennas followed by a second subnet and the one in this year's request is the first antenna in the second subnet. It is efficient and prudent to add these on a one-a-year basis and Goldstone is the first site that we are planning to put the new one. It is a copy of the antenna that we have

the basis that, legally, many of these jobs were not properly filled with contractor personnel. Was there ever a legal problem with these jobs and, if so, does there remain a legal problem?

Mr. ARMSTRONG. Let me address that, Mr. Chairman. In the study that was done, there were three types of contractor functions in question. One type was where we had work being done by contractors that should properly be done by civil servants, work such as preparing budgets and things of that nature. The second category included instances in which there was direct supervision of the contractor, which violates the personal service rules.

But a large number of the 4,000 involved support service contractors doing the research or gaining an experience that we thought should best reside in the civil service population. So of the 5,000 we were talking about, our request was only for the first two categories which amounted to 1,092. None of those in our opinion was illegal in that sense.

We had people doing things that we shouldn't have had them doing, but we did not breach the legality standpoint. Our IG did a review of the 500 that we had on the books and validated the fact that these were contractors doing the kinds of work that civil servants should do under the first two categories.

Mr. STOKES. In 1992, the committee provided sufficient monies to convert 500 contractor positions. NASA did not use that authority largely because of concerns expressed by the Senate committee. Have you made any effort to fill a selected number of the contractor jobs from within available monies outside of the CORE Program?

Mr. ARMSTRONG. Yes, we have, Mr. Chairman. Our response to the 1993 language was not to pursue CORE as a program, but rather put to use traditional resources to work on the material weaknesses that had been identified by replacing the contractors with civil servants as an opportunity arose.

So we identified those places where we think it can be done and we will continue it. It might not be as quick as it might be if we had proceeded under the original funding.

Mr. STOKES. Can you give us an idea how many.

Mr. ARMSTRONG. I will have to get that for you.

[The information follows:]

CORE PROGRAM

In FY 1992, there were about a dozen contractor jobs filled by civil servants using Personnel and Related Cost funds outside of the CORE program.

Mr. STOKES. Have any positions been converted back to credit or any new positions been newly filled with contractors?

Mr. ARMSTRONG. That is a fairly dynamic situation. As best I can tell, none of those have been converted back to contractors. We have not made another survey, but we are looking at support service contractors in a new study at the Headquarters and we will go into it later. But I think I can safely say before it is completed that we have not converted civil servant jobs back to contractors.

Mr. STOKES. Have any positions been newly filled with contractors?

Mr. ARMSTRONG. Here, again, I do not have that information. I do not believe it has been, but I will get you an answer.

Mr. STOKES. Provide that for the record.

[The information follows:]

CORE PROGRAM

No new civil service positions have been filled with contractors.

AGENCY-WIDE TRAVEL

Mr. STOKES. General Armstrong, last year NASA requested $55,492,000 for agency-wide travel and that number was reduced to $46,639,000, almost a $9 million reduction. Was any of that reduction offloaded on to the program accounts by changing definitions or using any other bookkeeping device?

Mr. ARMSTRONG. No, sir, that was the same question that was asked last year and our response is the same. We didn't do that. What we had to do is to cut back on travel and cut back on training, in order to fund the civil servants that we had on board that we had to pay.

Mr. STOKES. You are correct. Last year, Mr. Traxler, the chairman, asked Mr. Campbell if there had been any instances where travel had been charged against the program accounts rather than the appropriate travel object classification. And he responded that he checked that carefully and said, "I can find no occasion of this happening." Correct?

Mr. ARMSTRONG. That is true.

Mr. STOKES. You are confident that his statement and the situation in 1993 is correct and would withstand any IG investigation at this point?

Mr. ARMSTRONG. The part of the funds that I am responsible for is the R&PM funds, so if other funds were used for that, they would be in the funds that are managed by the Comptroller's Office, for instance. So I would defer the absolute answer to them.

Mr. ALLISON. And as far as I can tell, no instance has taken place like that. I think we could withstand any audit.

SENIOR EXECUTIVE SERVICE WORKFORCE

Mr. STOKES. On page SUM-5, the justifications indicate that part of the increase in 1994 will be devoted to lump sum payments due to the anticipated increase in requirements from the SES work force.

How much of the increase in funds requested in 1994 is earmarked for that requirement?

Mr. ARMSTRONG. We have listed $12 million for that. What we are talking about here is when a SES retires and accumulates annual leave, we pay them for that annual leave. We have a potential commitment above the $12 million if all 300 of our SES who were eligible for voluntary retirement leave.

What we have earmarked there is what we believe is a conservative view of what we may need to use from the R&PM account for lump sum payouts.

REIMBURSABLE DETAILEES

Mr. STOKES. Page SUM–7 of the justifications indicates that you provide for reimbursable detailees. How much money was devoted to that activity in 1992, and 1993?

Mr. ARMSTRONG. Let's see if I can find that. I don't have that right in my hands. It is my understanding that it is somewhere around $8 million, but let me give you that exact answer on that.

Mr. STOKES. Also, tell us how much is included in 1994, and how many reimbursable detailees are on board.

Mr. ARMSTRONG. I have data on the reimbursable detailees on board. Let me get that for you here. Most of the reimbursable detailees are from the Department of Defense.

Mr. STOKES. Why don't you just provide that for us for the record.

Mr. ARMSTRONG. Give me one more second, I think I have it because I anticipated the question.

Mr. STOKES. You just thought I might ask that question.

Mr. ARMSTRONG. There are 29 detailees at Headquarters. Some of those are from other NASA centers; A total of seven are from other governments agencies. The total in dollar value I will have to get you. That is from all over and that includes astronauts.

Mr. STOKES. Are you talking about reimbursable or nonreimbursable?

Mr. ARMSTRONG. The reimbursables are the ones that I am going to get you the data on. You asked a question about detailees, did you not?

Mr. STOKES. Reimbursable.

Mr. ARMSTRONG. I will give you that.

Mr. STOKES. And how many of those; that is what we need.

[The information follows:]

REIMBURSABLE DETAILEES

See the following material.

	1992		1993		1994	
	FTE	DOLLARS (thousands)	FTE	DOLLARS (thousands)	FTE	DOLLARS (thousands
JOHNSON	58	$5.9	60	$6.2	60	$6.5
AMES	3	$0.3	1	$0.1	0	$0.0
HEADQUARTERS	5	$0.5	5	$0.5	6	$0.6
TOTAL NASA	66	$6.7	66	$6.8	66	$7.1

The majority of the detailees at Johnson Space Center are members of the Astronaut corps.
Headquarters has a wide variety of detailee use: Space Shuttle, Space Station, security, NASA Aircraft office and international affairs.

ATTRITION RATE

Mr. STOKES. Last year we discussed the fact that the anticipated attrition rate had decreased significantly owing largely to the poor economy and the high retirement factor. General Armstrong indicated NASA had been achieving a roughly 8 to 9 percent attrition rate and last year it looked like it would end up at 3.0 percent.

What was the 1992 attrition experience and what is the 1993 level running to date?

Mr. ARMSTRONG. The 1992 attrition was 3.7 percent, which is roughly half of what we anticipated and had programmed before. This year we see it even lower. It is 3.1 right now. When attrition falls off below that which you programmed for, you pay for it in R&PM in two ways: You don't have the turnover of a high step to a lower step as you replace a person who leaves, and secondly, there is no lapse time in which the job is not filled. So the lower attrition rate hits us in two ways——

Mr. GOLDIN. It hits us in a third way. It doesn't allow us to replenish the labor force. And one of the major ideas that I have——

Mr. STOKES. We are going to cover that. On what basis is the 1994 submission made in terms of the attrition percentage?

[The information follows:]

ATTRITION RATE

The NASA attrition rate from 1992 to FY 1991 averaged 6.5 percent, the rate dropped dramatically beginning in FY 1992. The loss rate has declined steadily and we feel that the government-wide staffing reduction along with uncertainty about the economy will continue to support this decline in attrition.

When we prepared the FY 1994 budget in August 1992, we used a loss rate estimate of 4.7 percent (1117 losses) which seemed reasonable at that time. If the present decline continues, we would face higher than expected average salaries and might have difficulty funding our approved FTE levels.

Mr. ARMSTRONG. I believe we calculate that at 4 percent, but I will give you the exact number. There is a long form that we use that brings in a lot of numbers. I will get you that.

MINORITY HIRING IN SES POSITIONS

Mr. STOKES. Now we get to the question that you wanted to raise, Mr. Administrator. One of the problems is trying to hire the outstanding fresh-outs each year. It obviously derives from a lower attrition rate. The people at the top are those in jobs for many years that do not voluntarily leave NASA.

In terms of tight budget, it is hard to bring new fresh-outs aboard. In fiscal year 1991, out of a total of 593 fresh-outs hired, 60 were black, 170 in total were minorities.

[The information follows:]

FRESH-OUT HIRES

The actual freshouts hired in 1991 was 586. Of these 165 were black and other minorities. One hundred thirty-five (135) of the total of 165 minority hires were hired into scientific and engineering positions. Fifty-three (53) of the 165 total minority hires were black. Of these 35 were hired into scientific and engineering positions.

Mr. STOKES. While that represents a reasonable percentage, I would like for you to provide for the record how many of those

black and minority positions were hired into technical jobs as opposed to administrative and support functions.

The staff has asked NASA for a snapshot of your SES population distributed by nonminority and minorities. It is interesting that of the total NASA SES population, which at the end of fiscal year 1992 stood at 567 positions, only 14 were black and of those 14, only one was a female.

And what is more interesting is that 11 of the 14 were at headquarters, where of course, you are, while Ames, Langley, Goddard, Marshall, Stennis, and the Johnson Space Centers had no blacks in SES positions.

And the question we want to ask you, of course, is to what factors do you attribute these very low numbers?

Mr. GOLDIN. I am terribly, terribly concerned about this situation. I attribute it not to maliciousness. I attribute it to ignorance. We have had a gentleman named Byron Kunisawa come into NASA and hold sessions on cultural awareness, and as he goes through these sessions, we find that there is just not the level of sensitivity and understanding that is required to deal with the situation.

So we have asked our senior managers, Mr. Chairman, to develop a much more aggressive plan and to identify by year how they are going to begin to deal with the situation. General Armstrong's request provides you the details for that, but even at that, I still believe we have to do more. I believe we have to do a lot more.

In fact, one of the things we are going to have to look at is that we, in NASA, believe we need some help from the Government. We have a request into the Office of Personnel Management to allow us to give some incentives for early outs to allow headroom to bring in some new people, given that we have these very tight budgets and we want to keep a cap on the number of NASA employees.

I believe that this is going to be very, very important because, if we can't get movement, we have to create opportunity. And we are waiting for a response from the Office of Personnel Management and we will try and make it as creative a task as we can to try and deal with the situation because, for the people in place, I think it is inappropriate to say that we are going to pull you out of a job.

We want to create an opportunity for new openings and this may be one way to do it at the top. But we also have a problem with the feeder groups at the bottom. If you look at America, African-Americans make up something like 13 percent of the population and the outflow from the engineering schools right now is only 3 percent.

That is a very serious problem in and of itself, which is why NASA has undertaken to double the amount of money over a five-year period that we plan to give to the colleges and universities that have a high percentage of minority populations black universities and universities with a high number of Hispanic students and American Indians, or native Americans. So we have to do it across a broad front and we have to do a lot better.

Now, at Headquarters, we really have made some great progress. But I want to tell you that one of the things that Mr. Kunisawa talks about in his cultural awareness course is that there are a variety of qualities that one looks for in appointing people to senior

management positions including. Technical competence. But in addition, in our world, we have to have an awareness of multiculturalism that has to be a criteria that causes us to look at the qualities of different people.

As you pointed out yesterday, we are going to have a major number of Americans of different cultures coming into the work force and if our work force isn't trained in multiculturalism, we will never be able to break the paradigm. So we have a very, very aggressive program in training in multiculturalism for the senior managers so that they can be sensitive. As an Administrator, I am looking at each of them and establishing whether they are really serious about multiculturalism. This must be a criteria. That is the path that we are on, but we may come back to the Congress and ask for some help.

Mr. STOKES. I appreciate the forthrightness of your response. And I know it is an area that you are concerned about because you and I have had a number of discussions about it. And I am certain it is an area in which we have to continue cooperating with you in order to try and make some meaningful attack on this problem.

I have to tell you, I have sat on this committee many, many years. And yesterday when Dr. Wes Harris testified, it was the first time that I have seen a minority heading up one of the NASA programs coming before this committee to testify. The first time.

And while it is refreshing to see it, and the knowledge that we have someone of his qualifications appearing, we just have to do better.

Mr. GOLDIN. This is just the beginning, but we are going to need help at the top to help people that would like to leave, give them an extra incentive. I know that the DOD has had a program in place and I know that industry does it and I think we may need some help in NASA. Our intent is not to hurt people that are in place, but to enhance the labor force. And you are absolutely right, we have to do better.

PERSONNEL MOVEMENT

Mr. LEWIS. Mr. Chairman, there are a lot of other discussions in other committees on which you and I have served about this problem of people leaving. It may correct itself as a result of the high three circumstance. Not everybody is certain that it will solve these problems because agencies like yours have a variety and mix of personnel that are required.

And so we might very well want to look at some of those incentives that you are suggesting. I am not sure where that fits in the mix of things, but high three is not automatically going to do it in some instances.

Mr. GOLDIN. But in my mind, the thing that will do it most of all is what is in everybody's heart and soul because that is what is required to open up your mind to new possibilities and we have good people that have to change the way they look at other people.

Mr. STOKES. You know, you mentioned headroom. I guess the question is, that headroom should occur naturally, I would think, at the end of this year. This is the high three, right?

Mr. GOLDIN. Yes, we are hoping.

Mr. STOKES. We should have some movement in that direction.

Mr. ARMSTRONG. We estimate 120 would normally be leaving. Which would create some opportunities.

MINORITY/WOMEN-OWNED BUSINESS CONTRACTS

Mr. STOKES. Some opportunity for some movement there. For the record, also, Mr. Administrator, would you provide us by center and for headquarters how many black and minorities currently occupy GS-15 positions and how many of those positions are in technical slots.

[The information follows:]

CENTER/HEADQUARTERS BLACK AND MINORITY GS/GM-15 POSITIONS

Of the total 2551 GS/GM-15 positions, 59 were black and 110 are other minorities. Attached is a chart by Center of the GS/GM-15 population in scientific and engineering or professional administrative positions.

S&E Series by Minority Break GS/GM 15
AS OF 09/30/92

	HQS	ARC	LeRC	LaRC	GSFC	MSFC	SSC	JSC	KSC	TOTAL
Am Ind	1		1					2		4
Asian/PI	7	15	4	14	19	1		7		67
Black	15	2	3	4	6	2		1	1	34
Hispanic	9	4	1	1	8	1		7	3	34
Non-Minority	284	205	174	244	427	215	9	351	135	2044
TOTAL	316	226	183	263	460	219	9	368	139	2183

Prof Admin Series by Minority Break GS/GM 15
AS OF 09/30/92

	HQS	ARC	LeRC	LaRC	GSFC	MSFC	SSC	JSC	KSC	TOTAL
Am Ind										0
Asian/PI	1	1								2
Black	17	1	2	1	1	1		1	1	25
Hispanic	3									3
Non-Minority	193	19	11	12	45	16	3	25	14	338
TOTAL	214	21	13	13	46	17	3	26	15	368

Mr. STOKES. Let's talk for a moment about a similar situation, the area of contracting, minority and women-owned businesses where NASA and other Federal agencies have not afforded these entities equal opportunities to participate in garnering Federal contracts.

And of course, as you know, it was my amendment here in this committee a couple of years back that created the 8 percent set-aside for minority contracts. And of course this is another area in which I have had relatively extensive conversations and dialogue. I appreciate you telling me what progress has been made since you initiated increased efforts for minority participation. What are the numbers and percentage of minority and women-owned contracts? Such information and data as you have on this subject.

Mr. GOLDIN. I will be pleased to tell you. Last year at the close of fiscal 1992, we achieved a 7.2 percent involvement of women and minority-owned businesses at NASA as compared to a goal of 6.8 percent against a projection that looked like 5.4 percent early in the year. This was a direct result of the initiatives that we undertook in 1992.

We have a number of initiatives in 1993. I believe the most significant in 1993 is the formation of the Advisory Council on Minority-Owned Businesses under the leadership of Mr. Henry Wilfong. Dr. Freeman yesterday read the names of six Hispanic Americans that are participating in that. We have a broad cross-section of cultures on that committee. We have a broad cross-section of geographical locations on that committee and all of the people on the committee are part of the minority small business establishment in this country and they are there to advise us on how to be more effective. They have made an impact already. We took a self-imposed goal of getting to 8 percent by 1994. And we are going to try to shoot to see if we can make it in 1993.

CENTER/CONTRACTOR MINORITY/WOMEN-OWNED BUSINESSES

Mr. STOKES. Because we also think, if this is to work, you have to have the cooperation of both the centers and the contractors. It can't work otherwise unless you have full cooperation in terms of their assistance in meeting the kinds of goals that are being set.

What are you doing in that regard to get compliance from the centers and the contractors?

Mr. GOLDIN. Well, I will tell you, I was NASA Administrator for six weeks and I went down to the Aerospace Industries Association in Williamsburg last year, just about this time, and I spent almost half the allotted time of my speech talking about the commitment that the aerospace industries had to make towards bringing all of America into the NASA civil space program.

I have met one-on-one with Chief Executive Officers (CEOs) and identified to those CEOs where they have not been performing with regards to bringing in the cross-section of America. They have been very positive sessions, not angry sessions.

I am pleased to tell you that I went to a job fair that was held in Los Angeles, California sponsored by the Jet Propulsion Laboratory. 1200 members of the minority business community showed up for that job fair and I went around from booth to booth because we

had all our contractors and asked the contractors what are you doing? What do you think? I asked the members of the minority business community, is it worth your while?

We had contractors that traveled across the country to participate in this event and we had minority business people from across the country and they all told me the signal is out that NASA is very serious about doing business with minority-owned businesses. And it is not the Administrator. I believe the top team at NASA is committed to doing this and we have another distinguished person here, Ralph Thomas, whom I believe you have met. In his position, Ralph has the highest level in all the government agencies. You want to tell the chairman the position that you have and how it relates to other Federal agencies?

Mr. THOMAS. Every Federal agency is required to have an Office of the Small and Disadvantaged Business Utilization. My position is an associate administrator which makes me a part of the senior management team, the highest ranking person in that position in the Federal Government. And in that position, it gives me an opportunity to sit at the meetings where everyone here sits.

I know the priorities of the agency because I hear them, and that better allows me to advise minority and women contractors on where to focus their businesses. So that is just one of the things.

One of the things you said previously is: What are you doing to see that the message gets to the technical community? The efforts to reach the 8 percent goal are now in all the performance appraisals of all the Associate Administrators, particularly the Associate Administrators that have authority over our centers. It is also in the performance appraisals of our Center Directors. So that now the pressure to meet the goals is from the top down, rather than from the bottom up, and I believe that is the only agency that is doing that as well. This causes creativity, of course, and innovative approaches in meeting goals.

And one of the things that we did that no other Federal agency has ever done in the history of government is that we accomplished a Determination and Finding. We found in our Authorization Act that the head of the Agency can use other than full and open competition procedures if it is in the public interest to do so. We found that it is in the public interest to obey the law which is the 8 percent small disadvantaged business goal and we asked our Centers to identify contracts that could be set aside for small disadvantaged business-wide competition. They found 27 contracts totalling $314 million and we submitted this Determination and Finding to Congress.

Congress did not object in the allotted 30-day time frame and that is now in force. Our Centers are now developing and have already developed Requests for Proposals to put this set-aside in effect. This is another innovative process that has never been done, as is elevation of this issue to performance appraisals has never been done in a way that widespread. So I am very hopeful for this year and next fiscal year as well.

Mr. STOKES. Well, I am pleased to have those comments on the record. And, of course, I am very much aware of your background and commitment in this area. And I can say, Mr. Administrator,

recently Mr. Lewis and I traveled to Marshall, Stennis and to Kennedy.

And in the discussions we had there, it was apparent word was coming down or had come down with reference to these areas we are discussing with you. And to their credit, we found that there was an intention to comply with the edicts that they understood had come forth in this area.

Mr. GOLDIN. We do hope to do better, not because it is a social cause. We hope to do better because it is in the interest of the country.

Mr. STOKES. I agree with you totally.

Mr. Lewis?

MANAGEMENT CULTURE AT AMES RESEARCH CENTER

Mr. LEWIS. Mr. Chairman, just a couple of questions briefly.

I have the Betterton report on my mind. Admiral Betterton headed a management review team which issued a report last November regarding lax security at the Ames Research Center. The report stated that the Ames cultural environment was the underlying causes of NASA's vulnerability. Ames' credibility with the U.S. aerospace industry has been damaged.

I understand that your office has been involved in no less than six investigations as a result of the Betterton report. I understand that these violations continue to be under investigation by the FBI.

I am a little confused by the multiple statements coming from NASA regarding this. The Center director has suggested that management improvements stemming from the report would make Ames a model for other centers. Another NASA spokesman has suggested that we shouldn't make any conclusions until the FBI is finished.

How would you assess the situation based upon the leads which you pursued from the Betterton report and was the Admiral correct in his assessment that there is a flaw in the management culture at Ames?

Mr. GOLDIN. Let me say that I think the Director of NASA-Ames very seriously took the message of the Betterton report and, after we got over the issues of style and got to issues of substance, I believe that the management of NASA-Ames is getting very serious about identifying how they can address each of the issues in that report. We are going to work with them to help make Ames a better place because Ames is crucial to the future of aeronautics in this country. We have three Centers in NASA for aeronautics: Ames Research Center, Lewis Research Center, and Langley Research Center. And if the American aeronautics industry is not comfortable with the Centers, we are defeating the purpose of the whole program.

So I believe that the staff is now responding at Ames and I plan on going out and meeting with them personally, seeing the progress that they have made, and I am very, very hopeful that they will fix the issues identified with the management, including the sensitivity to diversity in the SES.

As I recollect, they only had one minority American in the SES ranks at Ames and there are multiple opportunities for promotion.

I am looking very seriously at the Center Director and waiting to see whether we are going to have an appropriate balance. NASA-Ames has the largest Asian community of any NASA Center, and has some of the most brilliant people in this country in this field. I am disappointed that more Asian-Americans haven't made it into the SES ranks. It is a broad range activity and a very painful process but I do believe they are responding now and I look forward to better performance. It is crucial to the future of our program.

PROCUREMENT PERSONNEL AND CONTRACT MANAGEMENT

Mr. LEWIS. Mr. Goldin, thank you for that. Among other things, GAO talked about the increase in procurement responsibilities and yet some ongoing difficulties relative to the percentage growth in numbers of personnel available in procurement.

The April 1993 procurement report says that NASA will obtain contract administration improvements by allocation of additional personnel to the contract management function and agency-wide training and contract and subcontract management.

The justification says that the 1994 budget allowed the agency to maintain training at a fiscal 1992 level. What specific steps does your 1994 budget request take to correct any shortage in training procurement personnel and contract management.

Ms. LEE. We are implementing, in conjunction with the training and specific career development programs dealing with procurement, core courses to bring all the people through the core and supplemental training for the specific areas that we have emphasis in. As far as the Agency material weakness is concerned, we have established in Headquarters a Division for Contract Administration. Subsequently, we asked each of the Centers to be sure that they have adequately addressed contract administration issues. And those issues include appropriate staffing—that can be an additional staff, and in some cases they have gotten additional head count or appropriate reallocation among the procurement people at that Center, or among the entire Center staffing, to be sure that we have the correct emphasis.

Mr. LEWIS. I have some refinements to the question and you will address them and add to it in the record.

Mr. Chairman, that is all the questions I have. Are we essentially through?

Mr. STOKES. We are past being essentially through.

PRESENTATION TO THE ADMINISTRATOR

Mr. LEWIS. If we are, and if you would allow me to take just a moment, I want to mention something special.

Mr. STOKES. Sure, I yield to you.

Mr. LEWIS. I was standing in the bathroom finishing shaving one early morning and I could hear the television set in the background. I wandered down the hall and stood there, just out of curiosity.

And I was watching my four youngsters see NASA send the first man to space. Their interaction was just really, really amazing. But within that group of four children was the apple of my eye, my daughter, talking about the apogee and the perigee.

Mr. Chairman, the Administrator's daughter is here with us today and I am sure she is as proud of her father as I hope that my daughter will be of me.

Mr. STOKES. We are pleased to have her here with you. Welcome. It is nice to have you here with us.

Mr. LEWIS. Can we make a special presentation to the Administrator. You can take it.

Mr. GOLDIN. "No whining." I will put this on my wall.

Mr. LEWIS. A little big for your jacket. You don't have to overdo this.

CHAIRMAN'S CLOSING REMARKS

Mr. STOKES. Well, let me just say, Mr. Administrator, I think as I have indicated, we are concluded. We have concluded our hearings. And we thought we might run a little longer than we have run actually, but I think we have had good, substantive hearings and I appreciate very much both the testimony of you and your associates. And we look forward to a continued working relationship with you and your associates, of course.

And we will reconvene, I am reminded, on June 14th for the purpose of the hearing on the redesign. And this committee will conduct a special hearing on the redesign once we know what it is. So we look forward to working with you in conjunction with having a good hearing on that.

This then concludes our hearing subject to the call of the chair. Thank you very much.

Responses to written questions submitted by Chrm. Stokes.

Interagency Agreements

I also serve on the Labor-Health and Human Services-Education Appropriations Subcommittee. In this capacity , I have taken a strong interest in the Memorandum of Agreement (MOA) you have entered into with NIH in this area. You may know, that I supported a similar MOA between NIH and NSF, to increase the numbers of minorities in biomedical and science careers.

QUESTION 1:

I am interested in whether your agreement has potential for overlap with the NIH/NSF effort?

ANSWER 1:

Enclosed please find a copy of the Memorandum of Understanding (MOU) signed on July 21, 1992 between the NASA and the National Institutes of Health (NIH). The objective of this collaborative effort is to increase the participation of the mainstream biomedical community in NASA's life and biomedical science program. The joint research program will seek to involve the best researchers and institutions in space life sciences research opportunities by providing supplements to ongoing NIH grants, funding of joint research centers at universities and medical schools, and soliciting and funding new individual grants. Cooperation with NIH will also lead to the development of new NASA Specialized Centers of Research and Training (NSCORT) and to the development of a new program of NASA supplements to ongoing NIH grants. NASA will take the lead in joint space flight research activities, and NIH will lead in joint ground-based research activities.

Although the MOU does not specifically address the subject of increasing minority participation in biomedical and science careers, NASA is committed to broadening the diversity of researchers involved in our programs. Offering greater space based research opportunities to a wide biomedical community, should help to increase minority participation in NASA's life and biomedical science program.

QUESTION 2:

I also note that NASA is investigating the possibility of a plan of cooperation with EPA. Where do you stand with this effort? What will the plan focus on?

ANSWER 2:

NASA and the Environmental Protection Agency (EPA) have a long history of cooperation in a variety of research areas. In October 1992, we signed a Memorandum of Understanding (MOU) on general cooperation with the EPA, which both updated and expanded our previous charter for cooperation. The MOU outlines the reasons for closer coordination between the two agencies and identifies a number of potential areas in which the parties might participate in information and data exchange and cooperation activities:

- o Earth and environmental science and measurements
- o Pollution monitoring, control, and prevention

- o Global climate and environmental change
- o Life sciences
- o Information systems and data management
- o Regulatory technical requirements development
- o Technology transfer, utilization, and commercialization
- o Aerodynamic and fuel efficiencies
- o Education and outreach
- o Such other areas as the Parties may agree upon

Since the signing of the MOU, NASA has been working with various offices in the EPA to draft implementing agreements in programs areas where both agencies have identified a near-term benefit. We anticipate that this effort will continue and expand over the coming year.

In addition, NASA regularly works with the EPA and other Federal departments and organizations through the Federal Coordinating Council on Science, Engineering and Technology (FCCSET) process, particularly in the area of global change research.

QUESTION 3:

What other Interagency cooperative agreements is NASA currently involved in? Are there others under consideration, and for what?

ANSWER 3:

See attached material.

MEMORANDUM OF UNDERSTANDING

BETWEEN THE

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

AND THE

NATIONAL INSTITUTES OF HEALTH

REGARDING

BIOMEDICAL AND BEHAVIORAL RESEARCH

1. SCOPE

The National Aeronautics and Space Administration (NASA) and the National Institutes of Health (NIH) within the Department of Health and Human Services agree that it is in the best interests of both agencies to develop a joint program of collaboration that enhances each agency's biomedical research capabilities. This Memorandum of Understanding (MOU) supersedes the previous MOU between NASA and NIH signed in June 1988. Specific agreements will be negotiated and entered into prior to the commencement of any activities pursuant to this MOU.

2. PURPOSE

The purpose of this MOU is to provide a set of guidelines under which cooperative activities between NASA and NIH may be implemented. This MOU is authorized by the National Aeronautics and Space Act of 1958 as amended, Section 203(c), which provides for cooperation between NASA and other Federal agencies.

3. DEFINITION

In this MOU, biomedical research is defined to consist of any life sciences research in space or on the Earth related to the biomedical changes in living organisms which are known to occur or could potentially occur during or after space flight, or to life sciences research on Earth that could benefit from the application or transfer of technologies specifically developed for space-related purposes, or to life sciences research in space or space-like environments that could improve knowledge of the basis for normal function of human organs and biologic systems on Earth.

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4. INTERAGENCY WORKING GROUP

The Interagency Working Group (IAWG) in biomedical and behavioral research established between NASA and NIH in 1988 will be continued. This IAWG will be co-chaired by NASA and the NIH. It will meet on a regular basis, at least once a year, to explore the need and feasibility of initiating cooperative programs and projects in biomedical and behavioral research and to review the performance of ongoing cooperative programs and projects. The IAWG will consist of an equal number of full members from NASA and NIH. Additional ad hoc members may be added for temporary assignments by either agency with prior concurrence of the co-chairpersons. The IAWG may establish, by mutual agreement of the co-chairpersons, an extramural advisory committee to examine the ongoing and planned joint activities and to advise the two agencies on the appropriate programmatic themes, priorities, and strategies necessary to yield a viable program within the available resources.

5. JOINT PROGRAMS AND PROJECTS

In general, joint cooperative programs between NASA and NIH may be initiated at any time that a specific agreement can be reached involving content, responsibility, liability, funding, and other appropriate provisions. All such joint programs are expected to capitalize on the strengths of each agency and to be mutually beneficial. It is expected that the NIH will have the lead role in ground-based research activities and that NASA will have the lead role in space flight research activities. The following cooperative activities are appropriate for implementation at the present time:

(1) The joint definition, funding, and management of focused university-based biomedical and behavioral research programs similar to the NIH Specialized Centers of Research (SCORs) or Program Project Grants, or to the NASA Specialized Centers of Research and Training (NSCORTs).

(2) The joint definition, funding, and management of a special flight experiments program of activities to enable greater numbers of biomedical and behavioral scientists to take advantage of access to the environment of space for research purposes. This program will be provided by NASA with a minimum of five (5) Shuttle middeck locker flight opportunities per year beginning in late 1993, and will also include additional space flight opportunities on future missions, such as those utilizing Spacelab (SLS-3 and SLS-4), Space Station Freedom, and, potentially non-U.S. space platforms (Mir, Biocosmos).

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(3) The joint development of a focused grant supplement program allowing NASA to fund supplementary awards to existing NIH SCORs, Program Project Grants, and Research Project Grants in order to carry out additional research tasks related to biomedical and behavioral research as defined in this MOU. It is expected that approximately ten (10) such awards to run concurrent with the larger NIH award will be made initially.

(4) The joint development of Program Announcements, Requests For Applications, and Requests For Proposals focused on increasing the number of individual investigator research tasks in selected areas of biomedical and behavioral research.

(5) The joint development of a comprehensive program of mutually sponsored workshops and regular symposia in specific biomedical research topics.

Other specific activities should be discussed at meetings of the IAWG and may be initiated once it is clear that they have the appropriate management support within the two agencies.

6. FUNDING

The ability of each agency to carry out its obligations as agreed to under this MOU is subject to the availability of the funding required to carry out those obligations.

7. TERMINATION

This MOU may be terminated by either agency at any time, provided a 90-day written notice is provided to the other agency and appropriate steps are taken to ensure an orderly termination of joint activities.

8. EFFECTIVE DATE

This MOU is effective on the date of signature by the agreeing parties and shall remain in effect until modified by mutual agreement between the two agencies.

Daniel S. Goldin Administrator National Aeronautics and Space Administration	7/21/92 Date	Bernadine P. Healy Director National Institutes of Health	July 21, 1992 Date

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MOU AGREEMENTS EXECUTED BY NASA 1992/1993

AGENCIES	TITLE	SIGNED
NASA/AGRIC. (Code S)	Collaborative Research Agreement for Gypsy Moth Experiment (AG-016)	8/92
NASA/DOE (Code I)	Energy-Related Civil Space Activities	7/92
NASA/USAF (Code J)	AFMC Support of NASA Projects, Programs & Operations (AF-275)	8/92
NASA/USAF (JSC)	Establishment of Specific Responsibilities for Performing Maintenance on FG33-P11 Engines	6/92
NASA/USAF (LaRC)	Cooperative Technology Efforts (AF-278)	
NASA/USAF	Joint Effort to Fill Toxicology Data Gaps and Perform Chemical Specific Risk Assessments for Chemical/Materials of Common Interest (AF-274)	7/92
NASA/USAF (Code D)	Transportation of Space Station Freedom Pprogram Hardware (AF279)	8/92
NASA/DOE (Code C)	Federal Technology Transfer Efforts	7/92
NASA/NIH (Code S)	Biomedical and Behavorial Research	7/92

doc:MOU

MOU AGREEMENTS EXECUTED BY NASA SINCE APRIL 1992

AGENCIES	TITLE	SIGNED
NASA/NOAA (GSFC)	GOES I-M Missions Operations	7/92
NASA/NSF (Code S)	Green Bank 140-Foot Telescope	7/92
**NASA/USDA (Code F)	Detail of USDA Supply Specialist to NASA	?/92
NASA/DOE (GSFC)	NASA Ground Operations Technology Testbed (GOTT)	6/92
NASA/USAF ((ARC)	Permit to Use Property on Edwards Air Force Base	6/92
NASA/USAF	Performing Maintenance on TF-33-P11 Engines	6/92
NASA/USAF (JSC)	Hazard Analyses, Tests, and Component Refurbishment Services (AF-281)	9/17/92
NASA/USAF JSC/	Responsibilities and Personnel Policies	12/2/92
NASA/USAF (Dryden)	Support of NASA F-15 Aircraft	1/11/93

PENDING MOU'S

AGENCIES	TITLE	
NASA/DOD (Code SE)	Research in Non-Acoustic Anti-Submarine Warfare	PENDING
NASA/NRL (Code S)	Reflight of MAHRSI on ATLAS Missions	PENDING
NASA/NIH (Code S)	Scientific Collaboration on the Aging Process	PENDING
NASA/NIH (Code S)	Deafness & Other Communication Disorders	PENDING
NASA/NIH (Code S)	Musculoskeletal Systems During Space Flight and on Earth	PENDING
NASA/DARPA NAVY/AF (Code R)	Enhanced Fighter Maneuverability (EFM) Flight Test Program	PENDING
NASA/DOC/DOE (Code I)	National Technology Initiative	PENDING
NASA/DOE (Code S)	ALEXIS (Array of Low Energy X-Ray Imaging Sensors)	PENDING
NASA/DOE/DOD (Code R)	Space Nuclear Propulsion Systems	PENDING
NASA/USAF (Code R)	The Propulsion Aerodynamics Controls Ingegration R & D Program (Rec'd from ID Williams 1/11/93)	PENDING

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PENDING MOU'S

AGENCIES	TITLE	
NASA/NIST (Code B)	A Digital Signature and Security Services (DS) System Project	PENDING
NASA/NIST (Code B)	Public Key Infrastructure Study	PENDING
NASA/DOE /DOD /NIST /NSF (Code R)	Defense Technology Conversion, Reinvestment and Transition	Recd 3/4/93
NASA/DOD (Code O)	Compatible Operations in the Mojave Desert Area	Recd 3/16/93
NASA/AF (Code J) (Code J)	Oklahoma City Air Logistics Center (OC/ALC) Support of NASA Projects & Aircraft Operations	Recd 3/18/93
NASA/AF KSC/Wright..	Research Project (Ground and Airborne Measurement of the Current and Electromagnetic Field Produced by	
NASA/AF	OC-ALC Support of NASA Projects & Aircraft Operations	Recd 3/93
NASA/DOD RF /ARPA	ASTOVL/CTOL Common Affordable Lightweight Fighter Technology Demonstration Program	Recd 4/7/93

PENDING MOU'S

AGENCIES	TITLE
NASA/NSF (Code FEH)	Experimental Program to Stimulate Competitive Research (EPSCoR) Program

Responses to written questions submitted by Cong. Jerry Lewis.

Planetary Exploration -- Cassini

Planetary exploration is at the heart of my notion of what NASA is all about and clearly in the current budget environment the Cassini mission to Saturn is the big winner. Indeed, in light of last year's funding decision which terminated the Comet Rendezvous Asteroid Flyby or CRAF component your request for $266.6 million is a sign that NASA is committed to keeping the United States in a position of world leadership when it comes to solar system exploration.

QUESTION 1:

I want to understand the science [of Cassini] just a bit better. The scientific goal is to help us understand the chemical building blocks of life in our Universe. The Project explores both the rings of Saturn and the nitrogen-rich atmosphere of Titan. How do those efforts translate into data that is relevant to our activities here on Earth?

ANSWER 1:

Titan, the largest natural satellite of Saturn, has an atmosphere composed primarily of nitrogen. It's atmosphere also has an oxygen component that is likely frozen on the surface in the form of water ice. If Titan were closer to the Sun, and was thereby warmer than it is today, its atmosphere might resemble that which existed on the early Earth.

Titan's atmosphere is also characterized by a brownish-orange haze composed of complex organic molecules, which form at high altitudes and "rain out" to the surface below. These organic molecules are based on carbon, and constitute the basic building blocks of life -- though they do not constitute life itself. While Titan is probably too cold for life to have endured, in many ways it could be a "chemical factory" of organic compounds much like the primordial Earth. Cassini's close-up observations of the composition and chemistry of Titan's atmosphere may help us understand better the chemistry of Earth -- from its very earliest stages of evolution to the present -- and how life came to develop here and nowhere else in the solar system.

The Saturnian system includes the most complex system of planetary rings in our solar system. These rings are believed to share many properties with the protoplanetary disc of gas and dust which surrounded our early Sun, and from which all the planets in our solar system evolved. Close-up studies by Cassini of the Saturn ring system's properties, including the distribution of different size particles and the composition of these particles, as well as the role of gravitational and electrical forces in shaping and maintaining these rings, will help scientists better understand the early evolutionary stages of both our solar system and planetary systems believed to surround other stars. Cassini will also help scientists explain how a diffuse gas disc collapsed and, through heating and collisions, accumulated into the planets of our solar system. It will also tell us a great deal about the dynamics by which these discs may have formed, or are forming, around other stars in the vast Universe.

In summary, the planets and moons of the outer solar system preserve in cold storage the archaeological record of the formation of the solar system and the early building blocks for life. By studying Saturn and its moons we can explore questions about Earth's distant past that help us understand how we got to where we are today -- how our own

atmosphere has developed to where it is today and how life as we know it emerged from the primordial Earth. All this provides additional information to answer the age-old questions about how life has evolved from basic building blocks into the vast diversity of living things found here on Earth today, and which may provide us with insights into the likelihood of discovering life elsewhere in the Universe.

QUESTION 2:

What is the status of the Cassini probe being provided by the European Space Agency?

ANSWER 2:

The "Huygens" probe being provided by the European Space Agency (ESA) for the Cassini mission is well along in its design and construction phase. ESA has recently completed a major system design review and all elements of the probe activity, including the integration interfaces with the spacecraft, appear on schedule to support the October 1997 launch date.

QUESTION 3:

The March 1993 Program Status Report which you provided to my office estimates that the Europeans will now be spending $500 million versus the original project estimate of $200 million. Tell me if you can how they react to project cost estimate increases of this nature. Maybe we can learn something from it. How much have they actually spent to date?

It appears that the original $200 million estimate that you refer to was for the Huygens probe hardware only. The current estimate for this hardware is only slightly higher than the original estimate: approximately $230-250 million.

The current $500 million estimate reflects the total life-cycle cost of all elements of the European contribution to the Cassini program, including support throughout the program to participating European scientists, hardware and software development and manufacturing, and all program testing.

To date, according to ESA they have spent approximately $77.16 million U.S. dollars on their contribution to the Cassini mission.

Jet Propulsion Laboratory Streamlining

JPL has issued announcements indicating that it will reduce its staff by 16.6 percent and discontinue testing at Edwards Air Force Base within the next five years. I gather that JPL is at the heart of the Cassini mission.

QUESTION 4:

How much money do you plan to save in operating costs at Jet Propulsion Laboratory (JPL) in FY 1994? Are any other programs besides Cassini affected by these reductions?

ANSWER 4:

The Jet Propulsion Laboratory is managing the Cassini project for NASA Headquarters.

The Cassini restructuring activities, and the associated management streamlining at JPL, have resulted in a projected savings of approximately $146.0 million during FY 1994. These changes will result in a net reduction of $270.2 million for the project through FY 1998.

The management restructuring at JPL will not be limited to the Cassini project, and we envision that all future projects will benefit from these changes.

In the area of operations costs, the Office of Space Science is conducting a detailed assessment of our Mission Operations and Data Analysis (MO&DA) funding requirements for our various missions. This ongoing assessment is focused on minimizing the programmatic impact of the recent general reductions in MO&DA funding and to properly apportion these reductions across our programs. Cassini is not directly affected by these reductions, since no MO&DA funds for Cassini are contained in the fiscal year 1994 budget request; Cassini's first year of MO&DA funding will be fiscal year 1998.

Aside from this general review of MO&DA funding requirements, NASA is also working with JPL to assess alternate operations architectures for the Cassini mission that could result in reduced operations costs over the life of the mission.

Red & Blue Team Assessments

In the oversight hearing which this subcommittee conducted on March 17, 1993, Mr. Aldrich discussed the practical impact of the blue and red team reviews for cost efficiency on FY 1994 programs. He mentioned that the Agency was able to reduce ongoing programs by $600 million and that these reductions were changes in scope NOT reductions caused by eating into planned reserves.

QUESTION 5:

Could you specify for us now which specific programs were affected by the reviews and allocate the $600 million on a program by program basis? What specific kinds of efficiencies make reductions of this magnitude possible?

ANSWER 5:

During the hearing, Dr. Fisk, NASA Chief Scientist described reforms which had been incorporated into the Space Science and Applications programs to reduce future funding requirements beginning in FY 1994. This discussion referred to a critical effort NASA undertook during the past year to reduce the projected runout of the agency's budget to a more realistic level, given today's constrained fiscal environment. The Red Team/Blue Team reviews referred to by Dr. Fisk, were a major element of this effort, and were a comprehensive examination of all of NASA's programs by NASA employees, to determine ways to undertake ongoing and planned programs faster, better, and cheaper. As a result of the Red Team/Blue Team reviews, incorporating Congressional direction to cancel the National Launch System and the Space Exploration Initiative efforts, and direction from OMB to restructure the Space Station, NASA's total funding requirements for FY 1994 through FY 1998 were reduced $23.8 billion, from $96.1 billion included in

the FY 1993 President's budget request for this timeframe, to $72.3 million included in the FY 1994 President's budget request. These savings were achieved through several actions, which include: implementing management and operational efficiencies on the Shuttle program; restructuring the Cassini, AXAF and EOS programs; reducing planned infrastructure requirements in Space Communications, Construction of Facilities and civil service; reducing the level of planned funding for mission operations and data associated with Space Science and Applications missions; and the Space Station Redesign. Enclosure 1 outlines the funding associated with these actions. This total reduction is offset by the addition of $8.1 billion in new contract, which includes investment in Shuttle safety and technology upgrades, funding to continue the development of the Gravity Probe-B mission, a major expansion of the Aeronautics program to support selected improvements in high speed civil transport research, subsonic long-haul aircraft. upgrades to national aeronautical facilities, and continued hypersonic research, and inclusion of a package on new technology investments. The exact size and scope of this Technology Initiative package will depend on the outcome of the Space Station redesign effort currently underway. Candidate elements for funding include: implementation of Technology Research Institutes at NASA centers; increased work in Automation and Robotics; development of small spacecraft technology and missions to test its application; additional research and analysis activities in Earth and Space Science; and, new efforts to develop advanced launch technology and improve existing commercial launch vehicles.

Centers for Commercial Development of Space

I understand that this Committee has attempted to exercise some control over the CCDS program. The Agency provided a mandated report to my office on February 3rd in the form of a performance review plan. <This program was initiated in 1985 and has grown to 17 individual centers.>

QUESTION 6:

Is this the first attempt to formally review the CCDS program since its inception in 1985?

ANSWER 6:

No. During 1986-1987, there were on-site reviews, by NASA and industry representatives, of the five CCDS's that received grants in 1985. However, these reviews lacked uniformity and consistent criteria. In 1987, a more in-depth review process was initiated which began with a full-day review of each CCDS to assess the CCDS's goals, objectives, and progress and evolved to an annual evaluation against commercial criteria. In 1992, a requirement for strategic planning which included a more formal long-range and annual business plan for each CCDS was initiated. These plans form the criteria and metrics for the CCDS reviews. Each CCDS will be reviewed annually to assess its progress in achieving its plan. Beginning in 1993, this process will be augmented by a triennial peer review.

QUESTION 7:

I'm a little concerned by the language contained on p.3 of the review plan.

> 'Because of the integrated nature of the CCDS program, termination of a Center would necessitate an Agency assessment of the effects of the termination on the total program."

FY 1994 P. ,ident's Budget
Five-Year Summary (FY 1994 - FY 1998)

REDUCTIONS

	FY 1993 Budget Runout	FY 1994 Budget Runout	△
	(Dollars in Billions)		
Space Station	15.1	7.1*	-8.0
Shuttle	22.8	19.4	-3.4
Infrastructure Reductions	18.5	15.7	-2.8
Space Communications	6.8	5.3	-1.5
Construction of Facilities	2.2	1.6	-0.6
Civil Service Costs	9.5	8.8	-0.7
Restructure	10.7	8.1	-2.6
CASSINI	1.7	1.4	-0.3
AXAF	1.9	1.6	-0.3
EOS	7.1	5.1	-2.0
Terminate NLS	3.0	0	-3.0
Terminate SEI	0.5	0	-0.5
Other Efficiencies & Reductions	25.5	22.0	-3.5
TOTAL	96.1	72.3	-23.8

*The Administration has not made a decision on the funding level for the Space Station. Three budget options are being examined and the exact funding level is dependent on the outcome of the Space Station redesign effort.

Enclosure 1

It sort of sounds like your have set up a system that requires a justification for killing the whole program in order to terminate a center rather than providing standards that would allow us to put a brake on the program's growth or even terminate an individual center if it fails to attract commercial interest. We have a similar Center based program for supercomputers at NSF and an individual Center was dropped from that program without destroying the network.

Am I misreading the Agency's intent here or does someone really believe that if one CCDS folds then the other 16 will come crashing down as well?

ANSWER 7:

The intent of the language contained on page 3 of the plan is not to imply that if one CCDS folds, the others will follow. It is meant to communicate that the technical areas being pursued may be synergetic. For example, flight opportunities are being provided for many CCDS's through the COMET, Sounding Rocket, and Wake Shield programs. The loss of a CCDS having a critical role in any of these programs would affect the availability of these carriers and, thus other CCDS's. Likewise, new technologies are being developed by one CCDS in areas important to the success of others (for example, a cooperative agreement between two CCDS's has one CCDS developing new data recording technology which is necessary for another CCDS flying a crystal growth experiment). The loss of this CCDS would impact others (CCDS/industry) if this technology pursuit were not continued elsewhere and will be addressed as part of the review process.

QUESTION 8:

Aside from the Commercial Experiment Transporter (COMET), which was developed through CSTAR at the University of Tennessee, are there other major successes you can point to in the CCDS Program?

ANSWER 8:

The CCDS Program has numerous successes which involve innovative space flight hardware development, a Sounding Rocket Program and the development of a Wake Shield Facility to utilize the high vacuum of space. In the conduct of CCDS flight experiments, major advances have been made. For example, growing larger and better protein crystals in space and the development of a facility to provide "batch" processing of space-grown proteins responds to the pharmaceutical industry need for better crystals for x-ray diffraction analyses of unique protein crystals in the development of new medicines. Polymer flight experiments on the Space Shuttle have provided results that may significantly enhance the production of higher quality polymer membranes for gas separation, food processing, pollution control and waste recovery; the first zeolite microgravity flight provided larger and better zeolites. Ultimately, these improved zeolites can be used for enhanced catalytic reactions, waste separation, and medical applications. Another example is a spin-off company from a CCDS specializing in using Global Positioning Satellite (GPS) data to update highway mapping for the Federal Highway Administration and 38 State highway departments. A second generation GPS van for updating U.S. highways data, e.g., roads, bridges, and roadway structures has been sold.

Since 1985, the number of industry affiliates to the CCDS Program has grown from 16 to

Since 1985, the number of industry affiliates to the CCDS Program has grown from 16 to 248 in 1992; the total number of patents approved has reached 13 while another 33 are in process; 1,182 publications have been published in referred journals; 13 companies have "spun" out of the CCDS's; a total of 43 STS flight experiments and 44 Sounding Rocket experiments have been flown; and over 300 students involved in the CCDS Program have been awarded either Bachelor, Masters, or Doctorate degrees.

QUESTION 9:

Exactly how does the Program work in terms of the financial participation of industry in each CCDS?

ANSWER 9:

Each CCDS develops a working relationship with an industry and sharply focuses on projects of mutual interest. The industry contributes the commercial justification, prior knowledge, and financial support through a continuation of active personnel participation in the research, cash transfer to the CCDS, and/or in-kind materials/services to the CCDS.

Industry commitment, and technical and business planning establish the near-, mid-, and long-term elements of the CCDS Program. The financial or leveraged funds from the industry demonstrates the industry "buy-in" and commitment. Discrete financial, patent, and licensing arrangements, and/or royalties negotiated between the CCDS and its industry partners form the basis of a multi-year agreement to proceed with each project. A criteria for successful performance of a CCDS is the amount of non-NASA cash and in-kind funding each CCDS can leverage from its industrial and other partners. This funding has continued to increase each year. In 1993, the CCDS (non-NASA) aggregate funding is projected to be almost twice NASA's base and experiment development funding placed on the CCDS grants.

QUESTION 10:

What percentage of a CCDS's budget is Federal and what percentage comes from industry?

ANSWER 10:

Because of the unique technologies and levels of program maturity at each CCDS, the percentage of funds leveraged varies with each CCDS. The total CCDS leveraged percentages for each fiscal year are shown below. NASA funding (Table A) represents the total expenditures for the base and experiment development grants; non-NASA Federal is all other Federal leveraged by the CCDS's. Industry includes cash and in-kind contributions. Table B portrays the funding profile for Sounding Rockets and COMET.

Table A

Fiscal Year	Funding: NASA	Funding: Non-NASA Federal	Funding: All Industry	Percentages: Federal	Percentages: Industry
1986	$4,512,000	$1,504,518	$7,738,428	44	56
1987	8,309,000	1,858,405	11,568,570	47	53
1988	17,177,450	5,820,458	14,309,302	62	38
1989	20,638,439	8,592,048	16,926,380	63	37
1990	23,562,689	6,527,883	19,465,125	61	39
1991	22,400,000	6,154,478	22,674,565	56	44
1992	27,300,000	4,322,000	30,550,320	51	49
1993*	29,500,000	4,505,000	36,704,044	48	52

* Estimate

Table B

	FY 1989	FY 1990	FY 1991	FY 1992	FY 1993
Sounding Rockets	$2,400,000	$3,600,000	$4,500,000	$2,100,000	-0-
COMET	-0-	-0-	10,500,000	18,000,000	$22,800,000

QUESTION 11:

The original goal was to allow each CCDS to encourage commercial products within 5 years. How many years should a CCDS operate before it can be completely taken over by its industrial and nonprofit partners or be terminated for failure to produce or encourage substantial commercial applications?

ANSWER 11:

The CCDS Program is an innovative approach to accomplish two goals: 1) reduce the cost for accessing and maximizing the use of the unique attributes of space, and 2) establish, through continuing focus and commitment, a series of business successes that will encourage more private sector investment to utilize the attributes of space.

The CCDS's are vehicles to organize industry around specific areas within a technology. To take a high risk technology from infancy to maturity in a commercial enterprise requires an excess of 10 years in the private sector. Doing this in space increases the risks. Where the regulatory authority becomes involved (FAA, FCC, FDA, etc.), the real time to market becomes longer. As the technology is matured, it will be transferred to the industry. Such a transfer would generally be expected to result in a return to the CCDS (such as a royalty or license); however, such a return is unlikely to be adequate to sustain the CCDS in the development of additional areas of technology.

We are at a point now where more rigorous success criteria have been developed and the CCDS's will be evaluated against this criteria. Termination for nonperformance for the CCDS's is defined in the performance evaluation "peer review" plan being implemented by NASA this year. A non-performing CCDS will be either terminated or placed on probation for 1 year and terminated if not able to adhere to successful performance criteria.

FISCAL YEAR 1994

BUDGET ESTIMATES

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RESEARCH &
DEVELOPMENT

SPACE FLIGHT,
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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1994 BUDGET ESTIMATES

GENERAL STATEMENT

The National Aeronautics and Space Administration (NASA) leads the United States' preeminent programs in aeronautics, space exploration, and flight activities for peaceful purposes. Its unique mission of exploration, discovery, and innovation has preserved the United States as both the leader in world aviation and as the preeminent spacefaring nation.

The NASA FY 1994 budget request of $15,265 million demonstrates the President's strong commitment to space and aeronautics. This budget concentrates on:

- Investing in the development of new technologies including a particularly aggressive program in aeronautical technology; to improve the competitive position of the United States, through shared involvement with industry and other government agencies;

- Continuing the nation's premier program of space exploration, to expand our knowledge of the solar system and the universe as well as the Earth, in an effort to understand the nature of global environmental problems; and

- Providing safe and assured access to space using both the Space Shuttle and Expendable Launch Vehicles.

This budget request strengthens the leadership position of NASA as an innovator and the future competitiveness of the United States by investing in the scientific and engineering community. NASA has undertaken a far reaching evaluation of all its activities to search for new ways of doing business and to find significant savings. Special teams conducted intense reviews of all the Agency's programs, and the results of these reviews have been incorporated into the NASA program. In addition, the President has directed NASA to undertake an intense effort to redesign the Space Station. Funding for the Space Station, activities which support utilization of the Space Station, and other initiatives to stimulate the development of new technology is included in the Space Station and New Technology Investments package. Details of these activities will be provided in June as part of the redesigned Space Station package.

Space Science and Applications

The Space Science and Applications program is designed to expand our understanding of scientific phenomena, ranging from the intricacies of the universe to the subtleties of the planet Earth. The FY 1994 budget provides for a carefully coordinated and logically phased set of research and development activities to:

- Advance our scientific knowledge of Earth and the global processes which shape our environment;
- Explore the solar system using automated spacecraft in conjunction with ground-based observations and research;
- Expand our comprehension of the universe beyond the solar system using the full range of capabilities from Explorer spacecraft to the "Great Observatories";
- Increase our knowledge in the life sciences on key issues ranging from human performance and habitation in space to the basic life processes and the potential of life elsewhere in the universe; and
- Understand and develop the potential benefits of the microgravity environment in materials sciences and other applications.

The Space Science and Applications program has been restructured into three new organizational elements. Space Science includes activities related to the exploration of the solar system, our understanding of the origin and evolution of the universe, the fundamental laws of physics, and the formation of the stars and planets. Life and Microgravity Sciences includes activities supporting use of the unique environment of space to increase our understanding of the impact of microgravity on the human body and the behavior of materials. Mission to Planet Earth includes activities which support increasing our understanding of the global environment as an integrated system.

Space Science

Development is continuing on the Advanced X-ray Astrophysics Facility (AXAF) and Cassini missions. The AXAF and Cassini programs have undergone significant revision to accommodate constrained outyear funding availability. The AXAF program now includes two missions. AXAF-I is scheduled for launch on the Space Shuttle in FY 1998, although NASA is actively pursuing procurement of a Titan IV expendable launch vehicle for this mission. AXAF-S is scheduled for launch in CY 1999 on a medium-class expendable launch vehicle. The AXAF-I will focus on high resolution imaging and dispersive spectroscopy, and the AXAF-S will perform high spectral resolution spectroscopy. The Cassini spacecraft has been redesigned to accommodate constrained funding in FY 1993 and a reduced total runout cost, while maintaining the October 1997 launch date and mission science objectives. Funding is also included to continue development of the Global

Geospace Science (GGS) Wind and Polar spacecraft, the ongoing Explorer program and the Gravity Probe-B mission. Funding to provide experiment hardware and research support for a Spacelab visit to the Russian Space Station Mir, scheduled for 1995, is included. This mission will augment ongoing data exchange on experimental results from Mir's long-duration missions. Mission Operations funding will support the Hubble Space Telescope servicing mission, scheduled for December 1993, and previously launched missions, including Mars Observer, Galileo, Ulysses, the Cosmic Background Explorer (COBE), the Extreme Ultraviolet Explorer (EUVE), and the Solar, Anomalous, and Magnetospheric Particle Explorer (SAMPEX). In addition, funding for science data management, archiving and science networking are also provided for under the Space Science program.

Life and Microgravity Sciences

Funding is included for continuing research activities in understanding the response of biological mechanisms and materials science to weightlessness, and the development of experiment hardware for use on the Space Shuttle. In Life Sciences, definition and development of experiments and hardware for Spacelab Life Sciences (SLS) series and other international flight opportunities will continue, including the 1995 Shuttle/Mir rendezvous mission. A main theme in the research conducted in Life Sciences is the use of gravity as an experimental variable to define the responses of biological systems to a micro- or zero-gravity environment. Funding is included to expand cooperation with the National Institute of Health (NIH) in biomedical research programs. Specific research initiatives are under development to expand participation of the mainstream biomedical community in the NASA Life Sciences program. NASA will have the lead in joint space flight research activities; NIH will lead in joint ground-based research activities.

Funding for Microgravity research will continue basic and applied research activities as well as the payload development effort, using Shuttle middeck, Spacelab, and cargo-bay experiments leading to several flights over the next few years, including the International Microgravity Laboratory (IML-2) mission, the U.S. Microgravity Laboratory (USML), and the U.S. Microgravity Payload (USMP) series. Funding to support the mission planning, management, and integration activities are included in this program.

Mission to Planet Earth

NASA is a major participant in the U.S. Global Change Research program. The Earth Observing System (EOS) and Earth Probes are the major NASA contributions to this program, and remain high priorities. Several changes have been made to the EOS program to reduce the program's overall cost, however, no change to the science objectives of the program have been made. Funding for the Earth Probes, which will address specific, highly-focused Earth science investigations requiring unique orbits or special sensor environments, is included. This program includes a Total Ozone Mapping Spectrometer (TOMS) free-flyer scheduled for launch in 1993, a TOMS instrument which will be launched aboard the Japanese ADEOS mission, the Scatterometer scheduled for launch in 1995, and the Tropical Rainfall Mapping Mission (TRMM) scheduled

for launch in 1997. In addition, a TOMS instrument was launched aboard a Soviet spacecraft in 1991. Mission Operations funding is included for the Upper Atmosphere Research Satellite (UARS) data analysis, which initiated the U.S. Global Change program. Funding is also included for continued development of Landsat-7, which is being managed by a joint NASA/DOD team. The data provided by Landsat-7 will be an integral part of the U.S. Global Change program. An active basic research program is also maintained.

Space Transportation

The Space Transportation program continues safe operation of the fleet of Space Shuttles, accomplishing seven flights during FY 1992. The Space Shuttle Endeavour flew its maiden voyage in May 1992, during which the Intelsat satellite was retrieved and repaired, and three new spacewalk records were set. Other missions accomplished during 1992 included two highly successful Spacelab missions focusing on Material Science, the first dedicated Astrophysics Laboratory (ATLAS-1) flight, launch of a DOD satellite, and the initial flight of the U.S. Italian Tether Satellite system.

The Shuttle program has undergone an intense review to reduce costs without sacrificing safety. Management operations efficiencies and program changes have been incorporated which result in significant savings. Funding for the highest priority Safety and Obsolescence Upgrade activities is included, as is funding for high risk Structural Spares items. Funding for the continued development of the Advanced Solid Rocket Motor is included. The budget provides for conducting eight missions per year as a baseline flight rate. Funding is included to purchase a docking mechanism from the Russians and make the necessary modifications to the Shuttle to support the planned rendezvous and docking with the Russian Space Station Mir and to support missions of up to 30 days.

Aeronautics Research and Technology

Aviation in general, and the aeronautics industry in particular, play a major role in supporting the economic strength, transportation infrastructure and national defense capabilities required for the long-term well being of the United States. Increased investment in aeronautics research, technology and facilities, as well as high-performance computing capabilities, is an important element in the President's plan to revitalize technology development to strengthen America's competitive position. The goal of the Aeronautics program is to conduct aeronautical research and develop technology to strengthen the U.S. leadership in civil and military aviation. This is accomplished by maintaining a broad-based research and technology program utilizing advanced facilities, laboratories, computers and technical staff, with extensive involvement of the U.S. university and industrial sectors.

This budget request maintains a strong commitment to develop a broad technology base in support of the aviation industry, enhance safety and capacity of the national airspace system, and assure U.S. superiority for national defense. Funded is including to augment the High Speed Civil Transport (HSCT) program by conducting research to develop the advanced propulsion, materials, aerodynamics, and flight deck

technologies that are required to assure future environmental compatibility, as well as economic viability. Funding is included for the Advanced Subsonic Technology program. This program will conduct advanced technology for aircraft noise reduction and major aviation system capacity increases through improvements in terminal area productivity. This program will take advantage of industry and Federal Aviation Administration (FAA) cooperation to accelerate applications of these advanced technologies to U.S. aircraft and engine manufacturers and to implement them in the National Aviation System. NASA will also continue as a full and active participant in the multiagency High-Performance Computing and Communications (HPCC) program. NASA's activities are focused on enabling broad advances in aerospace vehicle design, space and Earth systems science. This approach leverages current NASA leadership, while strengthening the capability for sustained high-performance computing research.

Transatmospheric Research and Technology

Funding is included to continue the Transatmospheric Research and Technology program, NASA's contribution to the National Aero-Space Plane (NASP) program. The program continues to make significant advances in the technology base. The technology base includes propulsion, materials and structures, control, and applications of computational fluid dynamics. High-risk program elements (primarily aeropropulsion) and hypersonic flight tests of critical technology elements are the near-term focus.

Advanced Concepts and Technology

A new organization, the Office of Advanced Concepts and Technology (OACT), was established in the fall of 1992 to improve the way in which NASA approaches the development and transfer of advanced technology, as well as the commercialization of space and space technologies. The process of integrating the activities of the Space Research and Technology program and the activities of the Office of Commercial Programs, will be completed in FY 1993.

The Space Research and Technology program develops the technology base on which our current and future capabilities in space depend. The Research and Technology program is responsive to the strong and continuing consensus that investments in advanced research and technology are essential to our future success in space. The program consists of two complementary parts: the Research and Technology (R&T) Base and the Civil Space Technology Initiative (CSTI). The R&T Base serves as the seedbed for new and innovative technologies and capability enhancement. The CSTI will continue to provide specifically for the development of selected technologies at larger scale or higher levels of maturity and, as required, in the relevant environment of space. This will facilitate a more effective technology transfer to the user programs, will reduce missions costs and increase safety and reliability.

NASA continues its commitment to encourage a healthy and expansive commercial space industry through the Technology Transfer and Commercial Use of Space programs. The FY 1994 budget request includes funding in support of the Centers for the Commercial Development of Space (CCDS) and to support the flight tests required by CCDS hardware development activities. The Commercial Middeck Augmentation Module (CMAM) will make its initial flight in FY 1993, providing expanded access to the space environment for experiments developed by the CCDSs. Initial flight of the COMmercial Experiment Transporter (COMET) is also planned for FY 1993.

NASA also seeks to involve the commercial sector in developing the infrastructure for research and working in space. Through the Technology Transfer program, we enhance and accelerate the application and use of aeronautics and space technology by the public, private and academic sectors.

Space and Ground Networks, Communications and Data Systems

The FY 1994 budget provides the vital spacecraft tracking, communications, telemetry, command, data acquisition, communications and data processing support to meet the requirements of all NASA flight projects. The Second Tracking and Data Relay Satellite System (TDRSS) Ground Terminal (STGT) will be operational in FY 1994 and work on the upgrade of the current White Sands Ground Terminal will continue. Launch of the Replacement TDRS (TDRS-7) is planned for 1995 on the Space Shuttle. Funding is included to procure replenishment TDRS spacecraft that are functionally equivalent to the current spacecraft.

Academic Programs

Science and mathematics achievement is an integral element of the National Education Goals, and NASA's Academic program strongly support making U.S. students first in the world in science and mathematics achievement by the year 2000. NASA's programs at the pre-college, college, and graduate levels are designed to capture and channel student interest in science, engineering, mathematics and technology as well as enhance teacher knowledge and skills related to these subjects. NASA is particularly committed to expanding the opportunities for women and underrepresented minorities in engineering, science and technologies. NASA is seeking to expand the future pipeline of workers to reflect the cultural diversity of the United States, by providing support, through research opportunities and fellowships, to students of underrepresented populations who are pursuing degrees in engineering and science. Funding is provided to Historically Black Colleges and Universities and other Minority Universities to allow them to build their research infrastructure and institutional capabilities. The programs which comprise the NASA education effort are supportive of national educational reform movements which are seeking to strengthen learning, teaching and assessment standards.

Institutional Capability

The NASA institutional capability is the fundamental underpinning for successful accomplishments of the Nation's Aeronautics and Space program. This capability is comprised of the people who plan, conduct and oversee the research, development and test activities of NASA, as well as the valuable and unique NASA facilities. The FY 1994 request provides for the necessary facility development and maintenance to support the NASA program and to support a Full-Time Equivalent (FTE) manpower level of 23,623.

The NASA facilities are unique national resources and are the key to maintaining our Nation's leadership position. The maintenance and modernization of these facilities is a high priority to protect the huge investment the Nation has made in them. The Aeronautical facilities are used not only by NASA but are also depended on heavily by the DOD and the U.S. industry, and are key to making the industry more competitive. A significant new initiative is included to expand the National Aeronautics Facilities Upgrade program begun in FY 1993 to improve the capability of these aeronautics facilities. Funding is also included to support facilities requirements for the EOS, Space Communications, and Space Flight programs.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FY 1994 BUDGET SUMMARY
(Millions of Dollars)

	Budget Plan		
	1992	1993	1994
RESEARCH AND DEVELOPMENT	6,827.6	7,089.3	7,712.3
Space station & new technology investments	2,002.8	2,122.5	2,300.0
Space transportation capability development	739.7	649.2	649.2
Physics and astronomy	1,036.7	1,103.8	1,074.7
Planetary exploration	534.2	473.7	557.2
Life sciences	157.6	140.5	
Life & microgravity sciences & applications			351.0
Space applications	985.1	1,148.0	
Mission to planet Earth			1,074.9
Space research and technology	309.2	272.7	298.2
Commercial programs	147.6	164.4	172.0
Aeronautical research and technology	788.2	865.6	1,020.7
Transatmospheric research and technology	4.1	--	80.0
Safety, reliability and quality assurance	33.6	32.7	35.3
Academic programs	66.8	92.9	74.5
Tracking and data advanced systems	22.0	23.3	24.6
SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS	5,384.8	5,086.0	5,316.9
Shuttle production and operational capability	1,296.4	1,053.0	1,189.6
Shuttle operations	3,029.3	3,016.0	3,006.5
Launch services	155.8	180.8	300.3
Space and ground networks, communications & data systems	903.3	836.2	820.5
CONSTRUCTION OF FACILITIES	531.4	525.0	545.3
RESEARCH AND PROGRAM MANAGEMENT	1,575.8	1,615.0	1,675.0
INSPECTOR GENERAL	13.9	15.1	15.5
TOTAL BUDGET AUTHORITY	14,333.5	14,330.4	15,265.0
OUTLAYS	13,959.9	14,077.6	14,670.0

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1994 ESTIMATES

SUMMARY RECONCILIATION OF APPROPRIATIONS TO BUDGET PLANS

(Millions of Dollars)

	TOTAL	R & D	SFC&DC	CofF	R&PM	IG
Fiscal Year 1992						
Appropriation P.L. 102-139	14,352,775	6,413,800	5,157,075	525,000	2,242,300	14,600
Appropriation Transfer P.L. 102-139	--	438,556	227,700	--	-666,256	--
Recission Pursuant to P.L. 102-298	-4,050	-4,050	--	--	--	--
Recission Pursuant to P.L. 102-389	-14,300	-14,300	--	--	--	--
Transfer Between Accounts	--	-6,400	--	6,400	--	--
Lapse of FY 1992 Unobligated Funds	-911	--	--	--	-188	-723
Total Budget Plan	14,333,514	6,827,606	5,384,775	531,400	1,575,856	13,877
Fiscal Year 1993						
Appropriation P.L. 102-389/Budget Plan	14,330,376	7,089,300	5,086,000	525,000	1,615,014	15,062
Proposed Supplemental	(4,696)	(4,696)	--	--	--	--
Total Budget Plan	14,330,376	7,089,300	5,086,000	525,000	1,615,014	15,062
Fiscal Year 1994						
Appropriation Request/Budget Plan	15,265,000	7,712,300	5,316,900	545,300	1,675,000	15,500

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1994 ESTIMATES

SUMMARY OF BUDGET PLANS BY INSTALLATION BY APPROPRIATION

(Thousands of Dollars)

	Total			Space Flight Control and Data Communications			Research and Development			Construction of Facilities			Research and Program Management		
	1992	1993	1994	1992	1993	1994	1992	1993	1994	1992	1993	1994	1992	1993	1994
Johnson Space Center	2,977,315	2,878,649	1,999,946	1,279,921	1,248,300	1,311,500	1,419,927	1,360,058	399,375	31,523	15,816	27,985	245,944	252,475	261,086
Kennedy Space Center	1,567,295	1,554,223	1,514,424	1,081,700	1,088,400	1,077,200	269,053	287,752	212,237	61,078	33,032	56,430	155,464	163,039	168,557
Marshall Space Flight Center .	3,144,023	2,988,362	2,700,410	1,893,400	1,678,301	1,839,120	962,507	1,005,716	580,633	56,459	69,813	37,010	231,657	234,730	242,847
Stennis Space Center.....	96,319	83,040	92,232	41,200	37,600	41,900	24,069	17,157	18,563	16,786	13,640	18,490	14,264	14,643	15,279
Goddard Space Flight Center ..	2,117,153	2,159,455	2,248,050	665,723	610,121	610,180	1,156,939	1,257,313	1,325,679	44,502	34,175	45,880	249,989	257,846	266,311
Jet Propulsion Laboratory	860,694	815,689	893,509	177,739	187,400	185,800	670,556	618,219	695,789	12,399	10,070	11,920	0	0	0
Ames Research Center	646,129	685,863	721,921	18,900	22,363	24,000	427,959	437,876	479,342	40,410	62,748	49,050	158,860	162,876	169,529
Langley Research Center	546,385	555,682	644,419	201	0	0	341,978	360,811	435,622	31,355	15,470	22,180	172,851	179,401	186,617
Lewis Research Center	939,399	1,013,649	791,613	64,700	46,500	145,700	679,608	762,995	409,884	22,765	23,820	50,260	172,326	178,334	185,769
Headquarters	1,212,738	1,340,658	1,120,936	161,291	167,015	81,500	875,010	1,001,603	855,176	1,936	370	5,255	174,501	171,470	179,005
Space Station (Under Review)	0	0	2,300,000	0	0	0	0	0	2,300,000	0	0	0	0	0	0
Undistributed Construction of Facilities:															
Various Locations	184,307	218,744	195,040	0	0	0	0	0	0	184,307	218,744	195,040	0	0	0
Facility Planning and Design	27,880	23,300	27,000	0	0	0	0	0	0	27,880	23,300	27,000	0	0	0
Total Budget Plan	14,319,637	14,315,314	15,249,500	5,384,775	5,086,000	5,316,900	8,827,606	7,089,500	7,712,300	531,400	525,000	545,300	1,575,856	1,615,014	1,675,000
Inspector General.....	13,877	15,062	15,500	---	---	---	---	---	---	---	---	---	---	---	---
Total Agency.....	14,333,514	14,330,376	15,265,000												

DISTRIBUTION OF FULL TIME EQUIVALENT WORKYEARS BY INSTALLATION

	1992 ACTUAL	1993 BUDGET ESTIMATE	1993 CURRENT ESTIMATE	1994 BUDGET ESTIMATE
JOHNSON SPACE CENTER	3,640	3,631	3,606	3,548
KENNEDY SPACE CENTER	2,543	2,510	2,508	2,467
MARSHALL SPACE FLIGHT CENTER	3,735	3,650	3,660	3,560
STENNIS SPACE CENTER	221	216	213	211
GODDARD SPACE FLIGHT CENTER	3,988	3,985	3,954	3,894
AMES RESEARCH CENTER	2,256	2,225	2,211	2,185
LANGLEY RESEARCH CENTER	2,946	2,925	2,914	2,869
LEWIS RESEARCH CENTER	2,799	2,787	2,757	2,725
HEADQUARTERS	1,932	2,006	1,934	1,924
SUBTOTAL, FULL-TIME PERMAMENT WORKYEARS	24,060	23,935	23,757	23,383
OTHER THAN FULL-TIME PERMAMENT WORKYEARS	270	296	232	240
SUBTOTAL, CEILING CONTROLLED FTE	24,330	24,231	23,989	23,623
CORE		500	0	0
GRAND TOTAL, CEILING CONTROLLED FTE	24,330	24,731	23,989	23,623

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1994 ESTIMATES

The FY 1994 multi-year budget estimate is submitted in accordance with the NASA FY 1989 Authorization Law (P.L. 100-685). The enclosed table contains the budget estimates for FY 1994, along with the Administration's projections for 1995 and 1996. The President has directed NASA to undertake an intense effort to redesign the Space Station. Funding for the Space Station, activities which support utilization of the Space Station, and other initiatives to stimulate the development of new technology is included in the Space Station and New Technology Investments package. Details of these activities will be provided in June as part of the redesigned Space Station package.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
FY 1994 MULTI-YEAR BUDGET ESTIMATES
IN MILLIONS OF REAL YEAR DOLLARS

FY 1994 PRESIDENT'S BUDGET	1992 PAST YEAR	1993 CURRENT YEAR	1994 BUDGET YEAR	1995 ESTIMATE	1996 ESTIMATE
RESEARCH & DEVELOPMENT	6,827.6	7,089.3	7,712.3	8,235.8	8,341.3
SPACE STATION & NEW TECHNOLOGY INVESTMENTS	2,002.8	2,122.5	2,300.0	2,300.0	2,300.0
SPACE TRANSPORTATION CAPABILITY DEV	739.7	649.2	649.2	643.3	639.0
PHYSICS AND ASTRONOMY	1,036.7	1,103.8	1,074.7	1,147.3	1,183.4
PLANETARY EXPLORATION	534.2	473.7	557.2	561.8	492.6
LIFE SCIENCES	157.6	140.5			
LIFE AND MICROGRAVITY SCIENCES AND APPLICATIONS			351.0	320.7	282.0
SPACE APPLICATIONS	985.1	1,148.0			
MISSION TO PLANET EARTH			1,074.9	1,448.1	1,508.4
SPACE RESEARCH AND TECHNOLOGY	309.2	272.7	298.2	333.1	372.1
COMMERCIAL PROGRAMS	147.6	164.4	172.0	141.4	132.7
AERONAUTICAL RESEARCH AND TECHNOLOGY	788.2	865.6	1,020.7	1,115.0	1,178.8
TRANSATMOSPHERIC RESEARCH AND TECHNOLOGY	4.1	0.0	80.0	80.0	100.0
SAFETY, RELIABILITY AND QUALITY ASSURANCE	33.6	32.7	35.3	38.5	40.1
ACADEMIC PROGRAMS	66.8	92.9	74.5	81.5	85.6
TRACKING AND DATA ADVANCED SYSTEMS	22.0	23.3	24.6	25.1	26.6
SPACE FLIGHT, CONTROL & DATA COMMUNICATIONS	5,384.8	5,086.0	5,316.9	5,371.0	5,658.2
SHUTTLE PRODUCTION AND OPERATIONAL CAPABILITY	1,296.4	1,053.0	1,189.6	1,232.3	1,250.6
SHUTTLE OPERATIONS	3,029.3	3,016.0	3,006.5	2,810.4	2,950.9
SPACE & GROUND NETWORKS, COMMUNICATIONS & DATA SYS	903.3	836.2	820.5	1,014.6	1,093.3
LAUNCH SERVICES	155.8	180.8	300.3	313.7	363.4
CONSTRUCTION OF FACILITIES	531.4	525.0	545.3	387.2	375.0
RESEARCH AND PROGRAM MANAGEMENT	1,575.8	1,615.0	1,675.0	1,703.0	1,752.0
INSPECTOR GENERAL	13.9	15.1	15.5	16.0	16.5
TOTAL	14,333.5	14,330.4	15,265.0	15,713.0	16,143.0

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1994 ESTIMATES

GENERAL STATEMENT

The objectives of the National Aeronautics and Space Administration program of research and development are to extend our knowledge of the Earth, its space environment, and the universe; to expand the technology for practical applications of space technology; to develop and improve manned and unmanned space vehicles; and to assure continued development of the long-term aeronautics and space research and technology necessary to accomplish national goals. These objectives are achieved through the following elements:

SPACE STATION AND NEW TECHNOLOGY INVESTMENTS: A program to provide for a redesigned Space Station, which will provide significant research capabilities in life sciences and materials science, and a series of new technology investments to contribute to U.S. scientific, technological and economic goals. The details of this package will be submitted to the Congress in June.

SPACE TRANSPORTATION CAPABILITY DEVELOPMENT: A program to provide for the development and use of capabilities primarily related to the Space Shuttle. The principal areas of activity in Space Transportation Capability Development are efforts associated with the development and operations of the Spacelab system for NASA Shuttle payloads; engineering and technical base support at the manned NASA centers; payload operations and support equipment; support for the planned Mir-Shuttle rendezvous and joint Spacelab mission; and advanced programs study and evaluation efforts.

SPACE SCIENCE: This program conducts a broad spectrum of scientific investigations to advance our knowledge of the sun, the planets, interplanetary and interstellar space, and the stars of our galaxy and the universe.

LIFE AND MICROGRAVITY SCIENCE: A program to identify and develop the technology for the useful applications of space techniques in the area of materials process research and experimentation, and to explore the effect of the zero-gravity environment of space on human physiology.

MISSION TO PLANET EARTH: A program to provide for the use of space systems, supported by ground-based and airborne observations, to acquire information which will assist in the solution of Earth resources and environmental problems.

SPACE RESEARCH AND TECHNOLOGY: A program of advanced research and technology development to ensure the technologies crucial to support current and future capabilities in space are available.

COMMERCIAL USE OF SPACE: A program to encourage increased industry investment and participation in high technology, space-based research and development, through expanded access to the space environment for experiments developed by the private sector, and the dissemination of advances achieved in NASA's research, technology and development program to both the public and private sectors.

AERONAUTICS RESEARCH AND TECHNOLOGY: A program to conduct the fundamental long-term research and to develop the discipline and systems technology required to maintain United States leadership in aeronautics.

SAFETY, RELIABILITY AND QUALITY ASSURANCE: A program to enhance the safety and technical execution of NASA programs.

ACADEMIC PROGRAMS: This program includes activities to support Agencywide university, minority university, and elementary and secondary school programs.

TRACKING AND DATA ADVANCED SYSTEM: This program includes activities to perform studies and provide for the development of systems and techniques leading to improve tracking and data program capabilities.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
RESEARCH AND DEVELOPMENT
FISCAL YEAR 1994 ESTIMATES

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Millions of Dollars)		
SPACE STATION & NEW TECHNOLOGY INVESTMENTS	2.002.8	2,250.0	2,122.5	2,300.0
SPACE TRANSPORTATION CAPABILITY DEVELOPMENT	739.7	863.7	649.2	649.2
PHYSICS AND ASTRONOMY	1.036.7	1,113.5	1,103.8	1,074.7
PLANETARY EXPLORATION	534.2	487.2	473.7	557.2
LIFE SCIENCES	157.6	177.2	140.5	
LIFE & MICROGRAVITY SCIENCES & APPLICATIONS				351.0
SPACE APPLICATIONS	985.1	1.207.1	1.148.0	
MISSION TO PLANET EARTH				1.074.9
SPACE RESEARCH AND TECHNOLOGY	309.2	332.0	272.7	298.2
COMMERCIAL PROGRAMS	147.6	171.6	164.4	172.0
AERONAUTICAL RESEARCH AND TECHNOLOGY	788.2	890.2	865.6	1.020.7
TRANSATMOSPHERIC RESEARCH AND TECHNOLOGY	4.1	80.0	--	80.0
SPACE EXPLORATION	(3.5)	31.8	--	--
SAFETY. RELIABILITY AND QUALITY ASSURANCE	33.6	32.5	32.7	35.3
ACADEMIC PROGRAMS	66.8	71.4	92.9	74.5
TRACKING AND DATA ADVANCED SYSTEMS	22.0	23.2	23.3	24.6
TOTAL	6,827.6	7,731.4	7,089.3	7,712.3

PROPOSED APPROPRIATION LANGUAGE

RESEARCH AND DEVELOPMENT

[(INCLUDING RESCISSION OF FUNDS)]

For necessary expenses, not otherwise provided for, including research, development, operations, services, minor construction, maintenance, repair, rehabilitation and modification of real and personal property; purchase, lease, charter, maintenance, and operation of mission and administrative aircraft, necessary for the conduct and support of aeronautical and space research and development activities of the National Aeronautics and Space Administration; not to exceed $35,000 for official reception and representation expenses; and purchase (not to exceed thirty-three for replacement only) and hire of passenger motor vehicles; [$7,089,300,000] *$7,638,300,000*, to remain available until September 30, [1994 *Provided*, That $2,100,000,000 shall be made available for implementing the restructured Space Station Freedom program without substantive deviation from the on-orbit assembly sequence outlined by NASA in March 1990, endorsed by the National Space Council, and confirmed by the Committees on Appropriations in House Report 102-226: *Provided further*, That $391,000,000 shall be made available for the development of the Earth Observing System (EOS) and EOS Data Information System (EOSDIS)] *1995*.

[Of the amounts made available under this heading in Public Law 102-139, $14,300,000 for the Climsat mission are rescinded.] *(Departments of Veterans Affairs and Housing and Urban Development, and Independent Agencies Appropriations Act, 1993.)*

In addition to amounts otherwise available under this head, and subject to the same terms and conditions, $74,000,000, for subsonic and high-speed research and technology development for short-haul civil aviation aircraft, and for the application of high performance computing and communications to various national needs.

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

RESEARCH AND DEVELOPMENT

REIMBURSABLE SUMMARY
(In thousands of dollars)

	Budget Plan		
	1992	1993	1994
Space station	2,417	2,833	440
Space transportation capability development	78,615	61,509	63,749
Physics and astronomy	9,170	3,420	5,574
Planetary exploration	405	461	490
Life sciences	825	1,007	
Life and microgravity sciences and applications			785
Space applications	435,733	589,472	
Mission to planet Earth			373,600
Space research and technology	22,324	33,312	34,344
Commercial programs	4,637	3,501	3,600
Aeronautical research and technology	58,600	74,577	76,889
Transatmospheric research and technology	20,050	21,887	22,566
Academic programs	246	602	386
Safety, reliability and quality assurance	647	791	770
Energy technology	19,706	19,890	20,507
Total	653,375	813,262	603,700

NATIONAL AERONAUTICS AND SPACE ADMINSTRATION

FISCAL YEAR 1994 ESTIMATES

DISTRIBUTION OF RESEARCH AND DEVELOPMENT BUDGET PLAN BY INSTALLATION AND FISCAL YEAR

(Thousands of Dollars)

Program		Total	Johnson Space Center	Kennedy Space Center	Marshall Space Flight Center	Stennis Space Center	Goddard Space Flt Center	Jet Propulsion Lab	Ames Research Center	Langley Research Center	Lewis Research Center	NASA HQ
Space Station & New	1992	2,002,745	976,469	87,800	424,375	---	75	4,089	1,455	3,609	307,805	197,068
Technology Investments	1993	2,122,467	946,967	101,200	471,300	---	---	2,600	1,000	3,500	364,800	231,100
	1994	2,300,000	UNDER REVIEW									
Space Trans Cap Dev	1992	739,711	282,800	156,400	219,400	16,100	11,800	400	---	1,000	800	51,011
	1993	649,216	239,600	142,300	188,400	9,600	11,600	---	---	1,500	1,100	55,116
	1994	649,200	183,800	178,000	196,300	10,400	8,600	400	---	1,900	1,400	68,400
Physics and Astronomy	1992	1,036,677	14,118	12,231	236,981	---	630,210	36,654	15,788	---	---	90,695
	1993	1,103,860	25,877	13,352	250,148	---	652,481	44,548	23,701	---	---	93,753
	1994	1,074,700	12	---	248,506	---	653,281	51,751	30,578	---	---	90,572
Planetary Exploration	1992	534,221	12,900	---	800	---	11,900	399,521	17,100	650	---	91,350
	1993	473,615	13,700	---	1,000	---	24,575	311,400	10,647	713	---	111,580
	1994	557,200	14,100	---	1,200	---	30,300	367,300	22,400	800	---	121,100
Life Sciences	1992	157,650	63,500	5,700	---	100	300	700	63,050	800	200	23,300
	1993	140,550	59,500	4,900	---	---	200	600	45,850	600	100	28,800
Life & Microgravity Sci	1994	351,000	118,884	24,758	89,360	---	300	10,182	31,700	2,200	36,800	36,816
Space Applications	1992	985,102	2,800	185	49,196	369	461,835	158,550	35,909	30,418	63,619	182,221
	1993	1,148,022	7,700	219	68,164	436	529,711	183,289	42,987	37,904	67,793	209,819
Mission To Planet Earth	1994	1,074,900	---	254	15,672	508	581,384	182,805	38,932	37,707	1,864	215,774

NATIONAL AERONAUTICS AND SPACE ADMINSTRATION

FISCAL TEAR 1994 ESTIMATES

DISTRIBUTION OF RESEARCH AND DEVELOPMENT BUDGET PLAN BY INSTALLATION AND FISCAL YEAR

(Thousands of Dollars)

Program		Total	Johnson Space Center	Kennedy Space Center	Marshall Space Flight Center	Stennis Space Center	Goddard Space Flt Center	Jet Propulsion Lab	Ames Research Center	Langley Research Center	Lewis Research Center	NASA HQ
Space Research & Tech	1992	309,172	15,090	2,673	25,202	640	21,845	44,186	31,643	55,066	72,939	39,888
	1993	272,729	6,550	2,380	20,000	270	16,803	49,450	23,906	47,525	64,703	41,142
	1994	298,200	7,700	3,800	23,300	300	23,800	56,700	28,600	50,600	66,300	37,100
Commercial Programs	1992	147,600	44,546	1,120	2,070	5,250	2,752	2,140	1,663	1,283	5,275	81,501
	1993	164,374	54,314	1,030	2,140	4,785	2,673	1,666	1,725	762	4,346	90,933
	1994	172,000	70,065	2,400	2,403	5,835	3,291	2,041	1,345	1,035	3,717	79,868
Technology Transfer	1992	32,500	4,546	320	970	750	1,452	640	763	1,083	775	21,201
	1993	29,495	2,495	380	1,000	785	1,298	675	1,225	527	880	20,230
	1994	26,900	905	560	1,483	635	1,775	925	1,045	996	1,205	17,371
Commercial Use Of Space	1992	115,100	40,000	800	1,100	4,500	1,300	1,500	900	200	4,500	60,300
	1993	134,879	51,819	650	1,140	4,000	1,375	991	500	235	3,466	70,703
	1994	145,100	69,160	1,840	920	5,200	1,516	1,116	300	39	2,512	62,497
Aero Research & Tech	1992	788,192	---	---	---	---	4,100	2,400	259,000	241,000	222,000	59,692
	1993	865,587	---	---	---	---	6,280	2,990	286,317	263,400	254,300	52,300
	1994	1,020,700	---	---	---	---	13,600	3,600	320,000	330,000	289,000	64,500
Transatmos Res & Tech	1992	4,136	---	---	10	---	---	---	901	2,250	893	82
	1993	0	---	---	---	---	---	---	---	---	---	---
	1994	80,000	---	---	---	---	---	---	4,000	7,000	5,000	64,000

NATIONAL AERONAUTICS AND SPACE ADMINSTRATION

FISCAL YEAR 1994 ESTIMATES

DISTRIBUTION OF RESEARCH AND DEVELOPMENT BUDGET PLAN BY INSTALLATION AND FISCAL YEAR

(Thousands of Dollars)

Program		Total	Johnson Space Center	Kennedy Space Center	Marshall Space Flight Center	Stennis Space Center	Goddard Space Flt Center	Jet Propulsion Lab	Ames Research Center	Langley Research Center	Lewis Research Center	NASA HQ
Safety,Reliability & QA	1992	33,600	3,914	1,818	2,636	620	4,268	5,370	150	2,282	4,232	8,310
	1993	32,707	2,936	1,101	2,059	713	4,591	3,126	221	2,107	3,982	11,871
	1994	35,300	2,140	1,925	1,660	480	2,771	1,390	350	2,066	4,136	18,382
Academic Programs	1992	66,800	3,790	1,126	1,837	990	1,754	1,146	1,300	3,620	1,845	49,392
	1993	92,900	2,914	1,270	2,505	1,353	2,026	2,150	1,522	2,600	1,871	74,689
	1994	74,500	2,674	1,100	2,232	1,040	1,952	2,020	1,437	2,314	1,667	58,064
Tracking & Data	1992	22,000	---	---	---	---	6,100	15,400	---	---	---	500
Advanced Systems	1993	23,273	---	---	---	---	6,373	16,400	---	---	---	500
	1994	24,600	---	---	---	---	6,400	17,600	---	---	---	600
TOTAL BUDGET PLAN	1992	6,827,606	1,419,927	269,053	962,507	24,069	1,156,939	670,556	427,959	341,978	679,608	875,010
	1993	7,089,300	1,360,058	267,752	1,005,716	17,157	1,257,313	618,219	437,876	360,611	762,995	1,001,603
	1994	7,712,300	399,375	212,237	580,633	18,563	1,325,679	695,789	479,342	435,622	409,884	855,176

NOTE: FY 1994 CENTER DISTRIBUTION DOES NOT REFLECT THE SPACE STATION AND NEW TECHNOLOGY INVESTMENTS FUNDING CURRENTLY UNDER REVIEW

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1994 ESTIMATES

BUDGET SUMMARY

SPACE STATION AND NEW TECHNOLOGY INVESTMENTS

SUMMARY OF RESOURCES REQUIREMENTS

	1994 Budget Estimate* (Thousands of Dollars)
Space station and related..... (Includes space station development, utilization, shuttle integration, facilities, research operations support, and transition costs, as well as augmented early flight research on extended duration shuttles and the Russian Mir station)	TBD
New technology investments.....	TBD
Total.....	2,300,000

In late February, the President outlined a new technology initiative entitled "Technology for America's Economic Growth, A New Direction to Build Economic Strength". This initiative recognizes that investments in technology offer new opportunities for creating higher-wage, higher-skills jobs, for a cleaner environment, for better schools and training, for more competitive businesses, for better health care, and for more efficient government. The initiative also recognizes that the best way for the Federal Government to ensure its investments are commercially relevant is through cost-shared and jointly-planned technology development partnerships with industry.

The President's initiative focuses on a broad range of technologies, including supercomputers, computer networks, advanced manufacturing, civil aviation, new automobiles, and educational technologies. NASA's ongoing programs, the redesigned Space Station, and the new technology activities described below provide a

significant contribution to the President's bold new initiative. What makes the new NASA technology investments so critical is that they are not focused just on major aerospace companies or old contract approaches but on developing novel (i.e., user driven) partnerships with and expertise in small businesses. It is, in fact, these smaller businesses that are expected to make the most significant contributions to the economy and to be the major creators of new jobs for our Nation.

Specific budget and program plans for each of these areas will be submitted to the Congress in June, consistent with the schedule for the Space Station redesign activity now in progress. Additional details are provided on the following pages.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1994 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SYSTEMS DEVELOPMENT

SPACE STATION FREEDOM PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate*
		(Thousands of Dollars)		
Development	1,996,745	2,200,000	2,115,467	
Assured crew return vehicle	6,000	15,000	7,000	
Operations	--	35,000	--	
Redesigned space station program	--	--	--	TBD
Total	2,002,745	2,250,000	2,122,467	TBD
Distribution of Program Amount by Installation				
Johnson Space Center	976,469	1,012,700	946,967	
Kennedy Space Center	87,800	156,200	101,200	
Marshall Space Flight Center	424,375	500,800	471,300	
Goddard Space Flight Center	75	--	--	
Jet Propulsion Laboratory	4,089	2,900	2,600	
Ames Research Center	1,455	100	1,000	
Langley Research Center	3,609	2,000	3,500	
Lewis Research Center	307,805	352,400	364,800	
Headquarters	197,068	222,900	231,100	
Total	2,002,745	2,250,000	2,122,467	

* FY 1994 funding is included in the combined budget summary for Space Station and New Technology Investments.

OFFICE OF SPACE SYSTEMS DEVELOPMENT

SPACE STATION AND RELATED ACTIVITIES

The Space Station Freedom program was initiated at the direction of President Reagan in 1984. Although specific program plans have been adjusted several times to reflect changing assumptions about funding and requirements, the principal objectives of the Space Station have remained the same: to contribute to U.S. preeminence in space-based science, technology, and manned space flight.

The Space Station program will enable unique scientific and technological investigations in a microgravity environment and provide the essential understanding of the ability of humans to live and work in space for extended periods. Commercial research opportunities will be provided and commercial applications will be encouraged. The program also provides a unique opportunity for cooperation with other nations demonstrating the peaceful use of space for the benefit of all.

However, the previously-planned Space Station program is unaffordable in light of total constraints on NASA's budget, funding needs of other NASA programs, recent Space Station cost growth, and recent Presidential direction for NASA to invest in new technology projects that can contribute sooner and more directly to the U.S. economy and technological/scientific goals.

The President has therefore ordered NASA to redesign the Space Station to greatly reduce program costs while still providing significant research capabilities. The Administration will submit to Congress a specific budget and program plan for the Space Station after several options for redesign and organizational restructure are assessed by an independent review panel. Completion of the independent review panel's assessment is planned for June of 1993. The budget will be based upon program management improvements and will include all activities related to Space Station development, operations, utilization, facilities, Shuttle integration, research operations support, and transition costs, as well as augmented early flight research on extended duration shuttles and in conjunction with the Russian Mir Space Station.

GUIDELINES FOR THE SPACE STATION REDESIGN

The Administration has established the following guidelines for redesign of the Space Station:

1. Provide the capability for significant long-duration space research in materials and life sciences during this decade;

2. Bring both near-term and long-term annual funding requirements within the constraints of the budget:

3. Continue to accommodate and encourage international participation; and

4. Reduce technical and programmatic risks to acceptable levels.

The selected design option for the new program should meet the constraints of:

1. Satisfying high priority research goals in materials and life sciences:

2. Supporting long-duration research (but not necessarily permanently manned):

3. Achieving initial on-orbit research capability by 1997;

4. Completing development within the 5-year budget plan;

5. Retaining opportunities for international partners participation. New opportunities for Russian participation should be considered;

6. Be configured for significantly lower cost operations;

7. Greatly reducing on-orbit assembly and checkout:

8. Implementing a simplified and effective program management structure:

9. Providing adequate budget reserves; and

10. Planning for a shorter on-orbit lifetime (e.g., 10 years extendable to 15 years).

The redesigned program will provide a meaningful and useful Space Station that will be a great value to the Nation. Its discoveries and advancements will contribute to future generations of yet unborn Americans. It, more importantly, is based upon the premise of a balanced NASA program of human spaceflight, robotic, planetary, and Earth orbiting spacecraft, technology, science and new aeronautics programs that will ensure America's preeminence in areas critical to the Nation's competitiveness.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1994 ESTIMATES

BUDGET SUMMARY

NEW TECHNOLOGY INVESTMENTS

SUMMARY OF RESOURCES REQUIREMENTS

	1994 Budget Estimate* (Thousands of Dollars)
New technology investments.....	TBD

OBJECTIVES

The President has challenged NASA to join in reinvigorating the health of the country's technological future and enhancing America's competitiveness in an increasingly competitive world. This technology initiative will take NASA in a new and exciting direction - new and cutting-edge technology, technology that counts its growth and maturity in a few short years versus decades, technology that clearly enhances this country's competitive leadership, and technology that takes advantage of the best and brightest minds of the Nation's universities. These technology investments will take advantage of the creativity and innovation of hundreds of small and culturally diverse entrepreneurs from all over America. These investments will provide defense conversion in a real sense, and benefit not just the aerospace industry but also other industries that contribute to the Nation's economy and well being.

These technology initiatives are enabled by the President's direction to redesign the Space Station which establishes a new direction for NASA's future. It shifts the emphasis away from a huge infrastructure that would have consumed almost two decades of effort and tens of billions of dollars, and committed the Nation to 30 years of increasing costs to operate. The new emphasis is on a less expensive and more flexible design that delivers on promised objectives, significantly reduces operations costs and is available in a reasonable time frame.

Most importantly, the Space Station redesign will allow implementation of a far-reaching new technology investment package. The elements of this package will emphasize focused, innovative approaches to push

technology development. It will provide opportunities to expand the participation of minority and women-owned businesses, academic institutions of all sizes, and entrepreneurial enterprises to work with NASA towards concentrating on demanding missions that utilize innovative technology that can in turn be applied on Earth to energize our industrial base.

These new technology initiatives in the NASA budget will create new jobs throughout the Nation. Additional jobs will be created by growth in NASA's ongoing programs, such as the Earth Observing System, the Advanced X-ray Astrophysics Facility, the Cassini mission, Shuttle flight activities and development upgrades, and challenging Aeronautics projects. The redesigned Space Station will necessarily result in some dislocations to certain elements of the program's workforce. However, other ongoing NASA programs and the new technology investments will provide additional opportunities that will more than offset any job losses resulting from the Space Station redesign.

NASA will gather views on implementation of new technology projects from a wide variety of voices across the Nation through a series of meetings. NASA will invite representatives from a broad spectrum of the business and academic communities to share their ideas on how to make new NASA projects more relevant to the American people. The success of forging new partnerships depends on improving communications. These meetings will provide a continuing dialogue with academia, industry and technology communities and groups that will receive the greatest benefit from NASA's new initiatives.

The new projects under consideration represent significant new opportunities for the aerospace industry, and open up the potential for strategic alliances between aerospace industry, universities and NASA so that all may work in concert. The new initiatives would likely be focused in three key areas of growth required for renewal of a vibrant American space and aeronautics program. First, new space and aeronautics technologies to fire the engines of American competitiveness and to revolutionize the capabilities of the American space and aeronautics program. Second, new flight programs that benefit from and build upon this new technology. Third, improvements in the Nation's expendable launch capabilities in order to launch the new wave of smaller and more frequent spaceflight missions.

Here are examples of new projects that could be proposed:

SPACE AND AERONAUTICS TECHNOLOGY DEVELOPMENT AND FLIGHT PROGRAMS:

- Technology Research Institutes - these would be consortia of aerospace industry with universities and NASA combined into one productive entity. They would combine the innovative creativity of industry and academia to expand our knowledge of science and technology for the benefit of space exploration, science and the quality of our life here on Earth. The Institutes would open up the facilities of NASA centers to aerospace industry and regional universities, promoting the joint development of dual-use technologies and early application and commercialization of products. The Institutes would also

serve as centers for graduate training and education of university students and aerospace workers. Selected improvement to various high-value research facilities at NASA centers would be considered to increase their value to these Institutes, and to bolster national competitiveness in Aeronautics and Space.

- Automation and Robotics - are key areas of technological and economic competitiveness that will help determine tomorrow's leaders in the world economy. New projects may be proposed in these areas to expand needed capabilities in NASA's programs. NASA's Earth observation satellites, deep space probes and astronomical satellites require ever more sophisticated automation and robotic mechanisms to increase their capabilities. Automated rendezvous and docking projects to enable robotic delivery of payloads to the Space Station and other space platforms could be started, including cooperative demonstration flights with Europe and/or Russia.

- Small Spacecraft Technology and Applications - this initiative would focus on pushing ultra-light, low-cost satellite and instrument technology through both novel data purchases and more traditional flight demonstrations. Small spacecraft technology has evolved significantly over the past several years. It appears that science missions using these technologies may now be developed and launched in less than two years and at significantly reduced cost. These technologies could be pushed through user-defined and competitively-selected data purchase partnerships involving the government, researchers, and industry. The government would pay for only its technology contributions if the data was not delivered. Several missions could be done each year providing useful science data and extensive training opportunities for the next generation of scientists and engineers. In addition, some portion of the funding would be used to further push this technology through joint NASA-industry technology flight demonstrations.

- Aeronautics - specific new technology initiatives in Aeronautics have already been approved by the Administration (see Aeronautics budget section), and additional new programs in this area are possible.

SCIENTIFIC EARTH SATELLITE AND DEEP SPACE FLIGHT PROGRAMS:

- New Small Earth Probes and Global Monitoring - could directly benefit from the Small Spacecraft Technology program to develop small Earth probes, and would fill information gaps using new and evolving capabilities. These probes could serve to continue long-term measurements of specific indicators of global change. These missions could involve creative cooperative arrangements, including data purchase agreements, with industry and universities to complement the current planned Earth Observing Satellite system of larger Earth science platforms.

- New Small Deep Space Probes for Science and Exploration - would provide increased opportunity for aerospace industry and university participation in NASA's Planetary Exploration program. Under consideration is a new series of low-cost "Discovery-class" planetary science missions similar to the Explorer-class of missions in the Physics and Astronomy line. Discovery-class missions would be constrained by highly focused science (few instruments), strict cost caps, short development times and use of the smallest launch vehicles capable of escape trajectories. Initial missions under consideration include: the Mars Environmental Survey (MESUR) Pathfinder project to develop the capability to place a scientific payload on the surface of Mars for less than 5 percent the cost of Viking, a Near-Earth Asteroid Rendezvous (NEAR) mission to explore one member of the class of objects that are a rich source of information about our solar system, and one or two small Lunar orbiters that could carry out the first post-Apollo scientific discovery flights to the Moon.

- Science Research and Analysis - would enable technology and software development for improved distribution and analysis of ongoing and new missions. Increased funding could expand the participation of minorities and women in NASA's scientific research program, could enhance the scientific capabilities of the Nation's universities in Earth and Space Science, and could provide for greater participation of graduate and undergraduate students in NASA's Earth and Space Science programs.

LAUNCH VEHICLE ADVANCEMENT PROGRAMS:

- Advanced Launch Technology - studies could further address advanced launch technologies and systems that could increase the cost-effectiveness of our access to space. Propulsion technology development and testing could be conducted on a cost-sharing basis with other agencies and industry to enhance current propulsion systems and develop lower cost engines. New and technically challenging propulsions systems, such as the hybrid rocket and other low cost propulsions systems, could be developed with the objective of attaining lower cost access to space and making the Nation's launch systems more competitive on the world market. Technologies could be pursued that would clearly establish the Nation as a leader in advanced launch systems.

- Expendable Launch Vehicle (ELV) Improvements - Product improvement programs could be defined that would improve existing expendable launch vehicle performance and reliability. NASA is considering funding contractor-managed upgrades in return for reduced prices on outyear launches. Another project being considered is a component advanced development program, in which NASA would develop technology for improved ELV components that could then be incorporated into ELV designs used for government missions.

In summary, NASA and the Administration are examining these and other potential new technology projects, and will submit specific program plans and budget information in June.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1994 ESTIMATES

BUDGET SUMMARY

OFFICES OF SPACE FLIGHT AND SPACE SYSTEMS DEVELOPMENT

SPACE TRANSPORTATION CAPABILITY DEVELOPMENT

SUMMARY OF RESOURCES REQUIREMENTS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate	Page Number
		(Thousands of Dollars)			
Spacelab	99,200	122,600	114,459	139,900	RD 2-3
Upper stages	41,200	(56,500)	(47,700)	(51,100)	RD 2-7
Engineering and technical base (ETB)	210,800	224,200	214,155	203,400	RD 2-8
Payload operations and support equipment	130,100	153,600	131,500	95,400	RD 2-12
Advanced programs	34,700	57,700	32,897	60,700	RD 2-14
New launch system (NLS)	28,000	125,000	10,042	--	RD 2-17
Tethered satellite system (TSS)	16,400	3,400	3,400	--	RD 2-18
Research operations support	179,311	177,200	142,763	149,800	RD 2-19
Total	739,711	863,700	649,216	649,200	
Distribution of Program Amount By Installation					
Johnson Space Center	282,800	302,400	239,600	183,800	
Kennedy Space Center	156,400	173,900	142,300	178,000	
Marshall Space Flight Center	219,400	298,000	188,400	196,300	
Stennis Space Center	16,100	22,900	9,600	10,400	
Goddard Space Flight Center	11,800	9,900	11,600	8,600	
Jet Propulsion Laboratory	400	400		400	
Langley Research Center	1,000	700	1,500	1,900	
Lewis Research Center	800	500	1,100	1,400	
Headquarters	51,011	55,000	55,116	68,400	
Total	739,711	863,700	649,216	649,200	

OFFICES OF SPACE FLIGHT AND SPACE SYSTEMS DEVELOPMENT

SPACE TRANSPORTATION PROGRAM

OBJECTIVES AND JUSTIFICATION

Space Transportation Capability Development funds a variety of activities which are needed to fully utilize the manned transportation program. Major activities include: (1) The Spacelab program; (2) the maintenance of an Engineering and Technical Base (ETB) at the Kennedy Space Center, the Marshall Space Flight Center, the Johnson Space Center, and the Stennis Space Center to serve as a source of technical expertise and capability to support the various projects; (3) Payload Operations and Support Equipment to provide critical services to NASA payloads; (4) an Advanced Programs activity needed to study, define, and develop technologies for new capabilities in manned transportation; and (5) funding for Research Operations Support (ROS).

Not included in FY 1994 are the Space Shuttle to Space Station mating and integration activities. The scope and funding for these activities will be driven by the Station redesign effort currently underway. A revised program plan consistent with the redesign proposal selected will be submitted to the Congress at a later date.

Beginning in FY 1993, Upper Stage vehicles are included in the Launch Services budget which is managed by the Office of Space Science. Management of the Solid Propulsion Integrity Program (SPIP) was moved from Upper Stages to Advanced Programs and is discussed in that section of this narrative.

BASIS OF FY 1994 FUNDING REQUIREMENT

SPACELAB

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Development	33,200	19,800	8,600	10,100
Operations	66,000	102,800	105,859	129,800
Total	99,200	122,600	114,459	139,900

OBJECTIVES AND STATUS

The Spacelab is a versatile, reusable facility designed for installation in the cargo bay of the orbiter. Spacelab can serve as both an observatory and a laboratory, thus giving scientists the opportunity to conduct a large variety of scientific experiments in the unique environment of space. Ten foreign nations, including nine members of the European Space Agency (ESA), have participated in this joint development program with NASA. ESA designed, developed, produced, and delivered the first Spacelab hardware, and NASA then procured an additional set of hardware from ESA under the terms of a ESA/NASA Memorandum of Understanding and an Intergovernmental Agreement.

There are two basic Spacelab configurations, modules and pallets. However, the hardware can be set up in a number of different combinations depending on the particular application, including using both modules and pallets on the same mission. The modules consist of one or two cylindrical shells enclosed by two end cones. Users may choose either a short module (one cylinder) or a long module (two cylinders) to meet their particular needs. There are no current plans for a short module. Each module contains a core segment housing basic subsystems (power, cooling, computers, data handling, etc) and an experiment segment carrying racks for conducting various experiments. The module is pressurized to allow a "shirt sleeve" working environment. Easy crew access from the Shuttle middeck during flight is provided by a pressurized tunnel. Modules are generally used for life sciences and space processing applications such as the United States Microgravity Laboratory (USML) and Space Life Sciences (SLS) missions.

Spacelab pallets are unpressurized and consist of multiple segments attached individually to the Orbiter, or up to three segments attached rigidly to each other, and to the Orbiter, in a continuous train. If pallets are flown without a module, essential subsystems can be carried in an "igloo" which provides a pressurized

and thermally controlled environment for the subsystem equipment. The igloo is not accessible to the crew inside the Orbiter. Experiments mounted on a pallet can be controlled from the orbiter cabin, from the ground, or from a module, if the payload complement contains a module. NASA has developed two principal versions of the Spacelab Pallet System (SPS). One supports missions requiring the use of the Spacelab computer system and pallet in a mixed cargo configuration like the Atmospheric Laboratory for Applications and Science (ATLAS) missions. The other version, the Enhanced Multiplexer/demultiplexer Pallet (EMP), supports missions such as the Tethered Satellite System (TSS), Lidar In-space Technology Experiment (LITE), and the Space Radar Laboratory (SRL) which do not require the use of the Spacelab computer system.

Spacelab development funding includes additional hardware to maintain the Spacelab carrier system, ground support equipment, hardware modifications, hardware acquisition, system recertification, and modified or improved hardware to expand Spacelab capabilities and ensure its continued operational availability. Support software and procedures development, testing, and training activities not provided by ESA, but which are required for the Spacelab, are also included in NASA's funding request. Additional Spacelab hardware, including spare hardware, is being procured from European and U.S. sources as needed to support the flight manifest.

The Spacelab operations budget includes mission planning, mission integration, and flight and ground operations. This includes integration of the flight hardware and software, mission independent crew training, system operations support, payload operations control support, payload processing, logistical support and sustaining engineering. The Spacelab operations cycle is repeated with each Spacelab flight but with a different payload complement. This cycle consists of three integration steps. Level IV covers the integration and checkout of experiment equipment with individual experiment mounting elements like racks and pallet segments. This activity is normally performed at the Kennedy Space Center (KSC) but is not part of the Spacelab Operations budget. Level II/III integration then combines and integrates all experiment mounting elements like racks, rack sets, and pallet segments, which have the experiment equipment already installed, and checks this out with the Spacelab software. This is done at the KSC and is funded under the Spacelab Operations budget. Level I integration takes the Spacelab and its payload, integrates it with the Shuttle orbiter, and then checks it out. Level I integration is performed by both the Spacelab contractor and the Shuttle Processing Contractor (SPC). The Spacelab budget funds that portion of Level I integration performed by the Spacelab contractor. The balance is funded in the Shuttle Operations budget.

Spacelab operations also funds smaller, tertiary and secondary payloads like Getaway Specials (GAS), Complex Autonomous Payloads (CAP), and Hitchhiker payloads. GAS payloads are research experiments which are flown in standard canisters and can fit either on the sidewall of the cargo bay or go across the bay (GAS bridge). They are the simplest of the small payloads with limited electrical and mechanical interfaces. To date, 87 GAS payloads have been flown and 33 are in preparation. The CAP missions utilize GAS hardware but are more complex because they utilize more services such as pointing and crew operations. Ten CAP missions have been flown and there are 5-10 opportunities per year. The Hitchhiker payloads are the most complex of the smaller payloads and they provide opportunities for larger, more sophisticated experiments. The Hitchhiker

is composed of two carriers depending upon whether it is attached to the sidewall or goes across the bay. During the mission, the Hitchhiker payloads can be controlled using the aft flight deck computer/standard switch panels or on the ground through a Payload Operations Control Center. Five Hitchhikers have been flown and additional flights are planned in FY 1993 and FY 1994 such as the Super-critical Helium On Orbit Transfer (SHOOT) experiment.

Another item funded in Spacelab operations is the Flight Support System (FSS). The FSS consists of three standard cradles with berthing and pointing systems along with avionics. It is used for on-orbit maintenance, repair, and retrieval of spacecraft. The FSS was used on Solar Max and Upper Atmosphere Research Satellite (UARS) and is required for Hubble Space Telescope (HST) repair/revisit missions.

In FY 1992 three Spacelab module missions were successfully completed. These were the International Microgravity Laboratory (IML-1), United States Microgravity Laboratory (USML-1), and the partially reimbursable Japanese Spacelab mission (SL-J). Three additional missions utilized Spacelab and Shuttle carriers in FY 1992: ATLAS-1, TSS-1, and one Hitchhiker which supported a DOD experiment.

In FY 1993, two Spacelab module missions are planned - the Space Life Science Laboratory-2 (SLS-2), and the partially reimbursable German Spacelab D-2 mission (SL-D2). In addition, the United States Microgravity Payload (USMP-1) has already been flown and an igloo/pallet mission, ATLAS-2, will also be flown. Along with these major missions are numerous smaller Shuttle carriers such as Hitchhikers and Getaway Specials.

In order to support a mid-1995 mission to dock with the Russian Space Station Mir, efforts will be initiated in FY 1993 to process a long module to be flown on this mission. The effort will be a scaled down version of a Spacelab Life Sciences flight. This will not only keep costs at a reasonable level and meet the schedule but will also provide early long duration medical data.

In addition to the support of these missions, analytical and physical integration, configuration management, and software development for future flights will be conducted. Procurement of spares for both NASA-developed hardware and for hardware developed by U.S. companies under contract with ESA will continue throughout FY 1993 and FY 1994 as will operation of the depot maintenance program.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The $8.2 million decrease is the net effect of reducing funding for planned replacements of obsolete hardware and new hardware acquisitions, identifying operational efficiencies and constraining changes to an absolute minimum, offset by required increases to support the Mir mission and the redistribution of ROS funding. Hardware replacement requirements will be continually assessed as manifest changes and operational experience dictate.

BASIS OF FY 1994 ESTIMATE

Beginning in FY 1994, development funds are required to perform the required modifications to Spacelab for Extended Duration Orbiter (EDO) missions of up to 30 days. These modifications, along with those made under the orbiter budget, would be needed to support Space Station in a man-tended mode as well as for operations in the orbiter on a standalone basis. This will provide an extended stay in space and allow a greater return on scientific experiments. These modifications include a high rate multiplexer upgrade and a video analog switch. The high rate multiplexer upgrade is needed to provide redundancy so that the payload data is protected against potential single point failures that might occur during these extended missions. The video switch is another added redundancy so that the video can be maintained. Other changes include modifications to the tunnel between the Space Shuttle and the Spacelab, an additional nitrogen tank, additional stowage, and other minor items. Spacelab development funding in FY 1994 will also continue to fund replacement of obsolete hardware so that current capabilities can be maintained.

FY 1994 operations funds reflect the program requirements to conduct Spacelab missions consistent with the budget manifest. Missions to be flown in FY 1994 include USMP-2, SRL-1, ATLAS-3, the International Microgravity Laboratory (IML-2), and the Lidar In-space Technology Experiment (LITE-I). Two new missions have been added to the Spacelab manifest since the previous budget. They are the Spacelab module mission to the Russian Space Station Mir and the Materials Science Laboratory (MSL-1) scheduled for launch in FY 1995 and FY 1997 respectively.

BASIS OF FY 1994 FUNDING REQUIREMENT

UPPER STAGES

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Development.....				
Procurement and operations.....	41,200	(56,500)	(47,700)	(51,100)
Total.....	41,200	(56,500)	(47,700)	(51,100)

Beginning in FY 1993, Upper Stage vehicles are funded within the Launch Servicea budget under the Office of Space Science. The Solid Propulsion Integrity Program (SPIP) is funded under Advanced Programs beginning in FY 1993.

BASIS OF FY 1994 FUNDING REQUIREMENT

ENGINEERING AND TECHNICAL BASE

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Research and test support.....	137,100	148,000	156,600	165,400
Data systems and flight support.....	18,200	17,300	9,400	--
Operations support.....	40,000	42,900	32,955	22,500
Launch systems support.....	15,500	16,000	15,200	15,500
Total.....	210,800	224,200	214,155	203,400

OBJECTIVES AND STATUS

The Engineering and Technical Base (ETB) provides basic engineering and technical capabilities to support the NASA mission assigned to the programs carried out by the manned space flight centers. The centers are: Johnson Space Center (JSC) including White Sands Test Facility (WSTF), Kennedy Space Center (KSC), Marshall Space Flight Center (MSFC), and the Stennis Space Center (SSC). It provides engineering and technical capabilities that can be utilized by project offices to carry out unique, R&D and analytical tasks. The tasks of any particular project would not justify investment in the facilities and personnel needed to undertake this R&D, but the requirements of a number of projects, combined with NASA's overall goal of enhancing U.S. aerospace technology, support the requirements for this capability. Additional unique requirements beyond the basic ETB functions of Research and Test Support, Operations Support, and Launch Systems Support are funded by the benefiting programs.

Research and Test Support funds the following activities:

- Personnel and materials needed to operate the engineering and science laboratories at JSC and MSFC. These laboratories do a variety of research in disciplines related to space flight, including life sciences, materials, manufacturing technology, propulsion systems, and life support systems. At JSC, this line supports work in altitude and vacuum chambers, materials testing labs, and a variety of other labs and simulators used to test and to gain understanding of how the space environment affects humans and hardware. JSC also funds testing at WSTF's propulsion test stands. At MSFC, the labs' research and test activities focus on propulsion systems materials, production processes, and environments. MSFC is working on applications of materials such as aluminum-lithium to launch vehicles, and has developed new manufacturing processes such as bonded-platelet combustion chambers. MSFC labs are also investigating spacecraft structures and avionics.

- Safety, Reliability, Maintainability, and Quality Assurance (SRM&QA) oversight at JSC, MSFC, and KSC. The funding supports an independent staff at all three centers to review space flight programs and ensure that the Agency's strict SRM&QA requirements are being met. In addition, KSC does analysis on the technical foundations needed to ensure that safety, reliability, and quality are engineered into current and future space vehicles. This R&D also helps to ensure that NASA's SRM&QA oversight is based on sound techniques and analysis.

- Super Computer (Class VI) operations at JSC and MSFC. These computers support a wide variety of engineering and technical research done in NASA's labs and in other labs associated with the Agency. The Class VI systems are used for modeling in the analysis of space flight environments and dynamics in order to improve our understanding of how getting to and living in space affects humans, other biological forms, materials, propulsion systems, avionics, and structures.

- Operation of MSFC's Technology Test Bed (TTB). The TTB is a highly instrumented platform to assess technology advances in liquid rocket engines. Starting in FY 1994, the TTB will be funded here rather than in the Space Shuttle Main Engine budget because this is a multi-program facility which supports a wide range of liquid rocket engine research. The TTB is used to provide a basic understanding of internal environments in large liquid rocket engines to help develop health monitoring and instrumentation systems to allow safer operation of future engines, and to test new developments in turbomachinery designs and materials.

The Data Systems and Flight Support budget line covers the JSC ADP operations, equipment, and supplies associated with Center's Information System and Network, Central Computer Facility, and the Integrated Software Technology Laboratory (ISTL). As a result of the phase-in of restructuring of the Agency's institutional budgets in FY 1993, part of the data systems and flight support was transferred to Research and Test Support and to benefiting programs within Research and Development.

Operations Support provides funds for maintenance and repair of the specialized equipment in the labs and test stands at MSFC, WSTF, and SSC. Examples of these include propulsion test stands and cryogenic facilities at MSFC and WSTF. Operations Support also funds engineering laboratory capabilities at SSC and the information resources management support at Headquarters.

Launch Systems Support covers scientific, engineering, and technical capabilities at the KSC which are focused on technologies to improve launch and payload processing. For example, the instrumentation and hazardous gas detection lab develops and tests new hazardous material and contaminant detection techniques as well as other improved sensors and instruments to aid in monitoring payload and launch preparations. The fiber optics and communications lab researches enhancements to the data, audio, and video links between KSC facilities. The Launch Equipment Test Facility (LETF) simulates launch events and conditions in order to

test and qualify new launch support equipment. The robotics lab is seeking ways to apply robotics to payload and launch processing. In addition to these R&D efforts, KSC support also provides launch site users with crucial services such as instrument calibration, Non-Destructive Evaluation (NDE), and chemical sampling and analysis.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The decrease of $10.0 million to ETB in FY 1993 incorporates a general Congressional reduction of $10.0 million. The general reduction will be achieved through operational efficiencies identified by the Centers including the consolidation of ADP and SRM&QA support contracts, improvements to management processes for documenting and tracking contractor performance, and elimination of repetitive operations in all functions. Adjustments were made to reflect a realignment of content to phase-in the Agency's institutional restructure in FY 1993.

BASIS OF FY 1994 BUDGET ESTIMATE

The FY 1994 estimate incorporates the completion of the restructure process in the ETB functions and reduces funding 3 percent below the FY 1993 level. This request will provide minimal support to the ETB infrastructure and will optimize the capabilities in place to support the NASA mission carried out by the Space Flight Centers. The activities previously discussed will be continued.

In Research and Test Support at JSC key facilities like the Electronic Systems Test Laboratory (ESTL) and the Crew Systems Laboratory will be supported. The ESTL will continue to provide a controlled, calibrated radio frequency environment for performing detailed functional performance evaluations of spacecraft communications equipment. The crew systems lab will continue to provide testing for the flight environment pressures for training flight crews in the operation of the extravehicular mobility unit. Funding will continue to enhance the computational capabilities at JSC and MSFC utilizing the Class VI super computers for solving complex main engine three dimensional dynamics modeling and complex structural analysis. Independent SRM&QA oversight is provided at JSC, KSC, and MSFC. ADP hardware and software support for laboratory operations at JSC is funded here. Also in FY 1994, the Technology Test Bed (TTB) program will be funded in this budget line.

FY 1994 operations funding in ETB will continue to provide technical support at MSFC, WSTF, and SSC. At MSFC, examples include photographic mission imaging support to laboratory functions of processing original still negatives and motion picture film and instrumentation services. Additional examples include: documentation repository for reproduction and microphotography operations related to handling engineering drawings and associated documents and specifications; certification of pressure vessels and systems, valve and component refurbishment; design, development, fabrication and installation of custom products such as space hardware shrouds, thermal blankets, wind shields, and clean room wall coverings; chemical analysis of

gases and fluids for tests; and maintenance and repair services for over 30,000 items of RDT&E equipment. At WSTF, the FY 1994 request supports the maintenance and operations of seven propulsion test stands and laboratory operations such as the test chambers and its supporting data acquisition and control systems (DACS). At SSC, laboratory capabilities for calibration, gas and materials processing, non-destructive evaluations, and fluid component processing will be continued. Headquarters information resources management capability is continued in FY 1994.

As a result of the restructuring of Agency's institutional support in 1994, all of data systems and flight support was transferred to Research and Test Support and to the benefiting programs.

The launch systems support at KSC will maintain scientific, engineering, and technical operations. The technical laboratories calibrate test equipment, review instrumentation reliability data, identify new equipment and measurement technologies, and develop software programs to control standalone and automated calibration. These laboratories also perform non-destructive evaluations including radiography inspection, ultrasonic testing, penetrant testing, and other inspection techniques. Engineering laboratories supported include instrumentation and hazardous gas detection, fiber optics and communications, and the expert systems laboratory. All of these laboratories help to fulfill KSC's role as the NASA space vehicle checkout and launch control center.

BASIS OF FY 1994 FUNDING REQUIREMENT

PAYLOAD OPERATIONS AND SUPPORT EQUIPMENT

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Payload operations.....	108,000	131,300	109,200	74,800
Payload support equipment.....	22,100	22,300	22,300	20,600
Total.....	130,100	153,600	131,500	95,400

OBJECTIVES AND STATUS

The objectives of the Payload Operations and Support Equipment budget are to provide payload services which are required beyond the standard Shuttle services for NASA missions, and to provide reusable support equipment for all payload operations. Optional services include items like: (1) retrieval services, analysis for rendezvous, and proximity operations, (2) special thermal analysis, (3) any modificationa to ground facilities particularly in the Shuttle Mission Simulator (SMS) above the standard service, (4) extra shifts required in the Shuttle Engineering Simulator (SES) or any other facilities to satisfy the customer requirements, (5) payload related Extravehicular Activity (EVA) above the standard service, (6) special training or use associated with operation of the Remote Manipulator System (RMS), (7) special services between the Payload Operations Control Center (POCC) and the Mission Control Center (MCC), and (8) any special analysis, testing, or other service not normally included in the standard Shuttle service. Also included is the development of an external airlock. This airlock will be a structure that will be used on OV-104 to support docking with the Russian Mir in 1995. While the inside airlock for OV-104 will be retained for this mission, having external airlocks is an operational requirement for Space Station because it frees up space in the crew compartment and thus enhances longer stay-times on-orbit. In addition, it provides increased payload performance by reducing weight. Payload operations also provides for the maintenance and operation of the Payload Processing Facilities (PPFs) at the launch site and payload-unique hardware to interface with the standard Shuttle payload accommodations.

Payload support equipment estimates reflect the development, testing, and delivery of payload accommodation equipment and capabilities common to multiple NASA missions. A major category is the communications equipment necessary for payload data transmission during ground processing and checkout. This includes fiber optic cabling and an upgraded operational intercom system in the industrial area at the KSC to provide increased flexibility and quality of data transmission among the various payload facilities. Orbiter/payload interface hardware for Hitchhiker, cargo bay cabling, modified aft flight deck panels, and associated displays and controls is also included.

CHANGES FROM FY 1993 BUDGET ESTIMATE

Payload operations and support equipment has decreased $22.1 million from the budget estimate. The primary reason is the reassessment of Space Station integration tasks. EMU requirements and orbiter power conversion units are examples of tasks which are being temporarily suspended pending the outcome of the station redesign effort. Partially offsetting this decrease are increases due to the addition of the external airlock.

BASIS OF FY 1994 ESTIMATE

In FY 1994 payload operations funding will continue to support payload services and mission unique integration for scheduled NASA missions. Major NASA missions receiving support in FY 1994 include Atlas-3, Spacehabs 2 and 3, HST Servicing Mission (HST-SM-1), International Extreme-UV Far-UV Hitchhiker (IEH), IML-2, SRL-1, USMP-2, and the Cryogenic Infrared Spectrometer Telescope for Atmosphere (Christa-Spas 01).

The Space Shuttle to Space Station mating and integration activities, which were previously budgeted in FY 1993, are not included in FY 1994. The scope and funding for these activities will be driven by the Station redesign effort currently underway. Once the redesign studies are complete, these requirements will be better defined and presented at a later date.

BASIS FOR FY 1994 FUNDING REQUIREMENT

ADVANCED PROGRAMS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Advanced transportation.....	14,900	20,300	9,500	18,400
Advanced operations.....	8,200	12,100	5,400	12,400
Advanced space systems.....	11,600	13,300	10,297	18,300
Solid propulsion integrity program (SPIP).....	(10,100)*	12,000	7,700	11,600
Total.....	34,700	57,700	32,897	60,700

*Included in Upper Stages prior to FY 1993.

OBJECTIVES AND STATUS

Advanced programs conducts concept feasibility studies, selected systems definitions and preliminary design (Phase B) studies, and undertakes related high leverage advanced development activities. These provide the necessary technical and programmatic data needed to identify evolving space transportation and systems requirements and to evaluate new technical capabilities. Activity is focused in four areas: (1) Advanced Transportation, (2) Advanced Operations, (3) Advanced Space Systems, and (4) the Solid Propulsion Integrity Program (SPIP).

Advanced transportation activities include both concept studies and advanced development. Studies define flight systems concepts and options for human trsnsportation, heavy lift launch vehicles, and advanced upper stages to satisfy near-term and longer range Agency space transportation requirements in sufficient detail to select cost effective pathways and guide technology. Near-term candidate systems under consideration include advanced boosters, personnel launch systems, and cargo transfer and return vehicles. More advanced concepts include fully reusable two-stage and single stage vehicles. The advanced development program focuses on demonstration and application of promising technologies to existing or new flight programs. Two major projects in this area are: the development and testing of electromechanical actuators, and the development of manufacturing techniques for aluminum lithium alloys.

The advanced operations program continues the pursuit of its goal of reducing the cost of ground and mission operations of the Space Shuttle through the introduction of advanced technologies into the operations environment. Estimated cost savings forecasted by the introduction of advanced operations projects into Space Shuttle mission operations in FY 1992 amounts to almost $5.0 million in annual savings through reduced manpower for mission operations computer support, orbiter process scheduling, and Space Shuttle software verification. Other advanced operations projects will significantly reduce the cost of producing replacement thermal protection tiles for the orbiter, training astronauts for the Spacehab missions, and scheduling Space Shuttle mission simulations.

The advanced space systems program includes concept definition and flight experiments in the following areas: system enabling flight demonstrations, orbital debris studies, and tether applications. Flight demonstrations also provide training for young NASA engineers and managers with early hands-on flight hardware experience. Successful flight demonstrations have been accomplished this past year with the Global Positioning System and Fluid Acquisition and Resupply Flight experiments. The orbital debris program is directed at measuring the orbital debris environment, developing debris growth mitigation measures, and enhancing spacecraft protection and survivability. NASA has continued to conduct measurements of the 1-10 cm debris population at Space Station/Space Shuttle altitudes. By the end of 1992, some 1200 hours of debris environment observations have been completed, reducing the uncertainty in that environment from some 300 percent to approximately 57 percent. The two Small Expendable Deployer System (SEDS) flight deployers and instrumented end masses as well as the Plasma/Motor Generator flight hardware will enable the demonstrations of tether initiated deployment as secondary payloads using the Delta II expendable rocket in mid FY 1993.

The Solid Propulsion Integrity Program (SPIP) was established in 1985 to enhance the nation's engineering data base for solid rocket motors in order to improve their success rate. Improved reliability is coming about as a result of developing and validating data bases and engineering tools for motor design, margins and performance analysis, reproducible fabrication and processing, verification, and by improving the culture across the nation's solid rocket motor infrastructure.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The current estimate reflects a net reduction of $24.8 million. This change is composed of a $25.0 million reduction in program content and a $0.2 million transfer due to the redistribution of ROS funds. The content reduction was accommodated by eliminating studies on the New Launch System (NLS), and significantly reducing ongoing activities in the following areas: support of advanced development activities; ground and flight operations studies; reduced SPIP nozzle, bondline and verification testing work; and deferral of several flight experiments.

BASIS OF FY 1994 ESTIMATE

In FY 1994, major program emphasis will continue to be placed on concept definition, system definition, and advanced development activities for advanced space transportation, advanced operations, advanced space systems, and SPIP. The FY 1994 funding request restores some of the program content originally planned in FY 1993 but deferred in order to accommodate the FY 1993 funding level.

Advanced transportation efforts will focus on developing a deeper understanding of concepts based on current technology which could replace or augment the Space Shuttle early next century. These studies will supplement and substantiate the trades and recommendations of the 1993 Access to Space Report. The increase from FY 1993 levels will allow continuation of advanced development efforts on electromechanical actuation, aluminum-lithium manufacturability, and initiation of vehicle health management. These technologies provide promise for direct infusion into current launch vehicles and will be needed to ensure that future vehicles will be operationally efficient, more reliable, cost effective, and provide improved performance margins.

Advanced operations efforts will continue to identify and demonstrate technologies which will improve efficiency, flexibility, and reliability of current and future space transportation systems. The selective application of expert systems, automation, and other technologies to labor-intensive and hazardous operations are included in advanced operations studies. Launch processing systems, mission control applications, flight planning, training, simulation and other environments will be targeted to demonstrate emerging technologies for improving ground and flight operations cost efficiencies. The requested level is significantly higher than current levels in FY 1993 in order to restart many of these advanced development projects that provide a significant return on investment.

Advanced space systems emphasis will be placed on the demonstration of transportation related flight systems. Flight Experiments, such as the Superfluid Helium On-Orbit Transfer (SHOOT) Demonstration and the Dexterous End Effector, will demonstrate enabling technologies in the space environment. Critical tether-related enabling technologies will be demonstrated using the Small Expendable Deployer System during FY 1994. Orbital debris activities will be focused on characterizing changes in the orbital debris environment as a function of time and establishing measures for mitigation of debris growth trends and spacecraft protection techniques. The increase from FY 1993 levels includes increases for orbital debris studies, initiation of a ground-based automated rendezvous and docking advanced development program, and attaining a sufficient level of flight demonstrations.

The SPIP will focus on nozzles, bondlines, verification testing, and on infusing technology engineering results and cultural changes into flight programs. In FY 1994, the program will continue to sustain the NASA/industry team and infrastructure across the U.S. solid motor community with steady advances in engineering data bases, analytical tools for design, fabrication and verification.

Additional Advanced programs activities are being considered for inclusion in the New Technology Investment package to be defined in June.

BASIS OF FY 1994 FUNDING REQUIREMENT

NEW LAUNCH SYSTEM (NLS)

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
New launch system (NLS).....	28,000	125,000	10,042	

OBJECTIVES AND STATUS

The NLS was to be a joint program with the DOD to develop a new family of launch vehicles. The goal of the program was to greatly improve national launch capability with reductions in operating costs and improvements in launch system reliability, responsiveness, and mission performance. Several NLS configurations with a range of capabilities were studied and an evolutionary path would have been maintained to support growth versions and technology improvements. The initial efforts were focused on developing the Space Transportation Main Engine (STME) since this was the common element of all configurations.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The current FY 1993 budget reflects a reduction of $115.0 million. This budget reduction terminates the effort on the NLS while retaining options to develop the STME and/or examine alternative engine technologies until national decisions are made regarding launch vehicles and the role NASA would take in engine development.

BASIS OF FY 1994 FUNDING REQUIREMENT

TETHERED SATELLITE SYSTEM

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Tethered satellite system (TSS).....	16.400	3.400	3.400	

OBJECTIVES AND STATUS

The Tether mission was flown on STS-46 in August 1992. Resources remaining from FY 1992 and FY 1993 will be used to do required post-mission analysis, flight anomaly testing and analysis, post-flight refurbishment, modifications to fix hardware problems, to place the hardware in storage, and to perform a feasibility study on the reflight of the Tether. At this time, no further Tether missions are manifested.

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BASIS OF FY 1994 FUNDING REQUIREMENT

RESEARCH OPERATIONS SUPPORT

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Research operations support.....	179,311	177,200	142,763	149,800

OBJECTIVES AND STATUS

Research Operations Support (ROS) funding provides vital support to the civil service workforce and to the physical plant at the centers and at NASA Headquarters. This funding supports the basic core administrative functions such as personnel, payroll, accounting, procurement, and legal counsel. It also supports centerwide services for civil service staff, such as mail, telephones, janitorial services, transportation, medical (other than astronaut), security, and fire protection as well as maintenance of roads, grounds, and all requirements of administrative buildings. Funding to support activities which directly benefit the NASA programs are included in the program budgets.

CHANGES FROM FY 1993 BUDGET ESTIMATE

In FY 1992, establishment of the ROS was initially accomplished by transferring funds contained in the Operation of Installation account in the Research and Program Management appropriation to the Research and Development and Space Flight, Control, and Data Communications appropriations. During FY 1993, a more detailed examination of activities supported by ROS funding was conducted by the program offices to identify support directly related to program activities. Funding for activities dedicated to a single program was transferred to the benefiting program. The decrease of $34.4 million reflects the transfer of $20.0 million consistent with a phase-in of restructuring activity and a reduction of $14.4 million consistent with Congressional action that reduced ROS funding.

BASIS OF FY 1994 ESTIMATE

The FY 1994 estimate is based on the completion of restructuring of the ROS budget in FY 1993. In addition, reductions have been implemented which reflect NASA's internal commitment to holding down costs in all areas and NASA's response to the recent executive order mandating reductions in administrative expenses. As such, it reflects the minimum funding to support administrative and facility maintenance requirements at the NASA centers and NASA headquarters. This includes administrative services that support civil service employees, facility maintenance, maintenance of roads, grounds, and requirements of administrative buildings.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1993 ESTIMATES

RESEARCH AND DEVELOPMENT BUDGET PLAN FOR SPACE SCIENCE AND APPLICATIONS

	Budget Plan				
		1993			
	1992 Actual	Budget Estimate	Current Estimate	1994 Budget Estimate	Page Number
		(Thousands of Dollars)			
Physics and astronomy	1,036,677	1,113,500	1,103,860	1,074,700	RD 3-1
Planetary exploration	534,221	487,200	473,615	557,200	RD 4-1
Life sciences	157,650	177,200	140,550	--	
Materials processing in space	120,800	195,300	172,934		
Life and microgravity sciences	--	--	--	351,000	RD 5-1
Earth science	725,393	868,500	863,848	--	
Communications	20,000	4,600	4,986	--	
Information systems	35,000	40,700	36,193	--	
Research operations support	83,909	98,000	70,061	--	
Mission to planet earth	--	--	--	1,074,900	RD 6-1
Total	2,713,650	2,985,000	2,866,047	3,057,800	

SPACE SCIENCE AND APPLICATIONS PROGRAM RESTRUCTURING

Beginning in FY 1994, the Office of Space Science and Applicationa program has been reorganized into three separate program offices -- the Office of Space Science, the Office of Life and Microgravity Sciences and Applications, and the Office of Mission to Planet Earth. The following program alignment has been budgeted as part of this reorganization.

Space Science supports the Physics and Astronomy and Planetary Exploration development, basic research and mission operations/data analysis programs as in previous years. It also includes the science data management, archiving and computer networking activities supporting the National Space Science Data Center (NSSDC) and NASA Science Internet, which had previously been budgeted under Space Applications - Information Systems. In addition, the Exobiology research program has also been transferred to Planetary Exploration to more accurately reflect the nature of the research conducted under this program. Shuttle/Spacelab Payload Mission Mangement and Integration, previously budgeted under Physics and Aatronomy, has been transferred to Life and Microgravity Sciences and Applications.

Life and Microgravity Sciences and Applications combines NASA's Life Sciences and Materials Processing programs together with their supporting Spacelab management function. Materials Processing, previously funded under Space Applications, has been renamed Microgravity Research, and remains a distinct element within the new structure. The addition of the Shuttle/Spacelab Payload Mission Mangement and Integration, which has been transferred from Physics and Astronomy, serves to consolidate the on-orbit research in these disciplines together with their associated space access infrastructure.

Mission to Planet Earth (MTPE) encompasses most of the activities previously funded under Space Applications. This includes: the Earth Science program; Information Systems functions which support MTPE (the NASA Center for Computational Science (NCCS) at the Goddard Space Flight Center and the supercomputing facility at the Jet Propulsion Laboratory); the Advanced Communications Technology Satellite (ACTS) program; and the Research Operations Support (ROS) program, which supports the basic core administrative functions at NASA's Goddard Space Flight Center and Headquarters. Elements previously included in Space Applications which are transferred into other program elements include the Materials Processing program (to Life and Microgravity Science and Applications), the space science data center activities associated with Information Systems (to Space Science), and the Search and Rescue program, which has been transferred to Commercial Use of Space to better take advantage of technology advancements.

An accompanying budget crosswalk displays the restructured elements.

SPACE SCIENCE & APPLICATIONS
FY 1994 Congressional Budget Crosswalk
(Dollars in Millions)

	TOTALS	Physics & Astronomy	Planetary Exploration	Life Sciences	Space Applications
Old Structure	3,058.9	1,165.9	546.7	154.4	1,191.9
New Structure	3,058.9				
SPACE SCIENCE	1,631.9				
Physics & Astronomy	1,074.7				
Programs that did not change	1,048.2	1,048.2			
Information Systems	26.5				26.5
Planetary Exploration	557.2				
Programs that did not change	430.8		430.8		
Research & Analysis	126.4		115.9	10.5	
LIFE AND MICROGRAVITY SCIENCE AND APPLICATIONS	351.0				
Shuttle/Spacelab Payload Msn. Mgmt. & Int.	117.7	117.7			
Life Sciences Research & Analysis	49.2			49.2	
Life Sciences Flight Experiments	94.7			94.7	
Microgravity Research & Analysis	18.4				18.4
Microgravity Flight Experiments	71.0				71.0
MISSION TO PLANET EARTH	1,074.9				
Programs that did not change	1,074.9				1,074.9
COMMERCIAL USE OF SPACE	1.1				
Search & Rescue	1.1				1.1

RD SSA-3

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1994 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE

PHYSICS & ASTRONOMY

SUMMARY OF RESOURCES REQUIREMENTS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate	Page Number
		(Thousands of Dollars)			
Advanced x-ray astrophysics facility development	150.740	174.000	168.337	260.300	RD 3-6
Gravity probe-b development	--	--	1.900	40.000	RD 3-9
Global geospace science	75.300	60.100	72.647	13.300	RD 3-12
Shuttle/spacelab payload mission management and integration	78.000	101.100	94.018	(117.700)	RD 5-17
Payload and instrument development	118.300	78.200	99.340	53.400	RD 3-14
Explorer development	109.100	112.500	115.832	123.300	RD 3-18
Mission operations and data analysis	375.200	440.900	415.385	416.200	RD 3-21
Research and analysis	69.937	81.400	71.558	72.200	RD 3-26
Suborbital program	60.100	65.300	64.843	69.500	RD 3-29
Information systems	--	--	--	26.500	RD 3-32
Total	1,036,677	1,113,500	1,103,860	1,074,700	
Distribution of Program Amount by Installation					
Kennedy Space Center	12.231	17.659	13.352	--	
Johnson Space Center	14.118	16.927	25.877	12	
Marshall Space Flight Center	236.981	261.577	250.148	248.506	
Goddard Space Flight Center	630.210	668.680	652.481	653.281	
Jet Propulsion Laboratory	36.654	51.558	44.548	51.751	
Ames Research Center	15.788	24.413	23.701	30.578	
Headquarters	90.695	72.686	93.753	90.572	
Total	1,036,677	1,113,500	1,103,860	1,074,700	

OFFICE OF SPACE SCIENCE

PHYSICS AND ASTRONOMY

OBJECTIVES AND JUSTIFICATION

Two programs are supported by funds provided under Physics and Astronomy: the Astrophysics program, dedicated to the study of the origin of the universe, fundamental laws of physics, and the nature and evolution of galaxies, stars, and planets; and the Space Physics program, dedicated to the study of cosmic ray plasmas, solar plasmas, and the Earth's and other planets' ionospheres and magnetospheres. Each program conducts development, operation, and research activities in their respective science disciplines.

The objectives of the Astrophysics program are to contribute to our understanding of the origin and evolution of the universe by studying astrophysical phenomena. These include large-scale structures such as galaxies, galactic clusters, and interstellar medium; and stellar objects such as quasars, neutron stars, pulsars, and black holes. Study of these phenomena contributes to knowledge about the formation of astrophysical objects and systems, as well as about the fundamental laws of physics. In addition to its astronomy missions, the Astrophysics program also supports a limited number of initiatives related to relativity science.

Astronomical observation from space allows observations to be conducted without being obscured or distorted by the atmosphere. Many infrared wavelengths are obscured and some wavelengths, such as x-ray and ultraviolet, cannot be observed from the surface of the Earth at all. Resolution of visible wavelengths is also improved when observed from space.

The objectives of the Astrophysics program are accomplished using a mixture of large multi-instrument observatories, medium- to small-sized Explorer spacecraft, instruments and payloads to be flown on international and U.S.-sponsored satellites and Shuttle/Spacelab flights, and airborne astronomy missions. Recently launched and currently operated spacecraft of the Astrophysics program include the Cosmic Background Explorer (COBE, 1989), the Hubble Space Telescope (HST, 1990), the Compton Gamma Ray Observatory (CGRO, 1991), and the Extreme Ultraviolet Explorer (EUVE, 1992). Recent Spacelab missions include the Astro-1 (1990), an astrophysics portion of the Atmospheric Laboratory for Applications and Science (ATLAS-1, 1992), and the Diffuse X-ray Spectrometer (DXS, 1993). NASA also supported the deployment and operation of the international Roentgen Satellite (ROSAT, 1990).

The attention of NASA's Space Physics program is upon naturally-occurring plasmas, the physical state of 99 percent of the universe. Relatively cool plasmas in the planetary ionospheres, the hot plasma of the sun, Earth's and other planets' magnetospheres, and galactic cosmic-ray plasma are all the focus of study supported by the Space Physics program.

Flight programs of the Space Physics program are concentrated on the sun, the heliosphere of naturally occurring plasmas which it generates, and its impact on and relationship to the magnetic, electrical, and atmospheric systems of the Earth. Study of Earth's nearby space environment has revealed a dynamic and complex system of plasmas interacting with the magnetic fields and electric currents surrounding our planet. This region, comprising the magnetized solar-wind plasma plus the perturbation in the heliosphere caused by the presence of the magnetic Earth, is the region defined as the geospace.

Medium-size satellites, Explorer spacecraft, instruments flown on international satellites, balloons, and brief sounding rocket experiments are used to observe and to provide in-situ measures of the geospace. In addition, operation of the Ulysses satellite, and other planetary missions which have exited the solar system, is performed under this program's sponsorship. Studies performed by this program provide crucial details across a range of astronomical, Earth, and basic science disciplines.

Space Physics missions undertaken recently include the Combined Release and Radiation Effects Satellite (CRRES, 1990), the Solar, Anomalous, and Magnetospheric Particle Explorer (SAMPEX, 1992), space physics instruments on the ATLAS-1, 1992 Spacelab mission, and the international Solar-A/Yohkoh (1991) and Geotail missions (1992).

The Astrophysics program is currently developing the Advanced X-ray Astrophysics Facility (AXAF), the Gravity Probe-B (GP-B) relativity experiment, the X-ray Timing Explorer (XTE), the Fast Auroral Snapshot Explorer (FAST), and the Submillimeter Wave Astronomy Satellite (SWAS). The medium-sized Advanced Composition Explorer (ACE), previously funded under Other Explorers, will transition into development in FY 1994.

The AXAF, approved by Congress in FY 1989 as a demonstration of mirror fabrication and testing, has proceeded with science instrument development, continued fabrication and test of its large grazing incidence mirrors, and early design of spacecraft, telescope, and mirror assemblies. Following a restructuring of this system in 1992, AXAF is now composed of two satellites to be launched in 1998 and 1999. Together, the two satellites will provide high resolution imaging and both wide-band and narrow-band coverage of the x-ray spectrum, necessary for both cataloging study and specific investigation of the composition and nature of galaxies, stellar objects, and interstellar phenomena, and the study of basic issues in theoretical physics.

The GP-B is a unique test of Einstein's general theory of relativity. After a lengthy period of science definition, technology demonstration, and design and test of prototypical components, GP-B has been judged to be ready to begin development for flight. Ongoing development of the Shuttle Test of Relavity Experiment (STORE), an in-flight demonstration of GP-B instrument performance funded under Payload and Instrument Development, will continue to support the GP-B satellite development program.

The XTE, SWAS, FAST, and ACE are all funded under the Explorer program. NASA selects Explorer missions to conduct investigations of an exploratory or survey nature, or to achieve specific objectives which do not require the capabilities of a large spacecraft or observatory. The SWAS and FAST are classified as Small Explorers (SMEX).

Ongoing development of systems needed for modification and repair of the Hubble Space Telescope is also supported under the Physics and Astronomy program. A modified science instrument, corrective optics for three other instruments, two new solar arrays, and other subsystems are in development for the December 1993 servicing mission. Other development work related to future servicing missions and to ongoing improvement of ground systems is also supported.

Currently, the HST can resolve spatial features by a factor of ten better than ground-based optical telescopes, or objects as dim as the 24th magnitude. Full capability to observe objects from the 25th to the 28th magnitude, originally planned for Hubble, will be restored by the 1993 servicing mission with the Wide Field/Planetary Camera II (WF/PC II) instrument and the Corrective Optics Space Telescope Axial Replacement (COSTAR) system. This increased capability will allow extended use of the Faint Object Camera (FOC) and Faint Object Spectrograph (FOS) and improved use of the Goddard High Resolution Spectrometer (GHRS). Future enhancements of HST will extend the system's coverage into the infrared and greatly enhance the spectral resolution, efficiency, and sensitivity of HST's ultraviolet coverage. These improvements will allow astronomers to address basic questions concerning the origin, evolution, and disposition of galaxies, quasars, clusters, and stars, allowing us to increase significantly our understanding of both the early and present universe.

The Space Physics program is currently developing two satellites under the Global Geospace Science (GGS) program and several instruments and spacecraft subsystems under the Collaborative Solar Terrestrial Research (COSTR) program. COSTR instruments and subsystems will be used on several international satellites. These two NASA programs represent the U.S. contribution to the International Solar Terrestrial Physics (ISTP) program, a broad initiative to conduct advanced observations and study of the sun and Earth's geospace. Under this program, satellites are being developed by NASA and the European Space Agency (ESA), plus one satellite already produced by the Japanese Institute of Space and Aeronautical Science (ISAS).

NASA's two GGS spacecraft, Wind and Polar, together with Japan's Geotail which was launched in 1992 and other Earth observing and near-Earth satellites, will make the first coordinated geospace measurements of

the interaction between the Earth's magnetic field and plasma from the sun, and the transfer of mass, energy, and heat to the Earth system. Wind will study this transfer at the head of the geospace, Polar at Earth's poles, and Geotail at a point where the Earth's magnetic region tails away.

NASA's COSTR program will provide instruments and subsystems for the European Solar and Heliospheric Observatory (SOHO) and four Cluster spacecraft, in addition to the support already provided for the Japanese Geotail spacecraft launched in 1992. SOHO will measure the interior dynamics, magnetic field structure, and output of the sun. Cluster will conduct special 3-dimensional studies of isolated regions within the solar wind and geospace to provide an in-situ metric of plasma flow. Together, the ISTP program will provide a comprehensive understanding of the sun-Earth interaction and its coupling to Earth's climate.

The Astrophysics and Space Physics programs also support the development of a number of instruments and payloads to be used on international satellites or on Spacelab missions. Launch services, scientific guidance, and ground operations support are sometimes linked to NASA's contribution to these programs.

During the past several years, suborbital observation from balloons, sounding rockets, and high-flying aircraft took on increased significance. This enhanced effort will continue to provide observations and instrument development opportunities for research groups. Furthermore, increased emphasis will also continue in the research and analysis (R&A) and the mission operations and data analysis (MO&DA) areas in order to maintain a vital research base.

Both the Astrophysics and Space Physics programs rest on a solid basis of supporting research and new technology development, research, and theory-building. Research teams at NASA centers and at universities, industrial laboratories, and other government laboratories are supported. The scientific information obtained and the technology developed in this program are made available to the scientific communities and the general public for application to the advancement of scientific knowledge, education and technology.

Shuttle/Spacelab mission management and integration of Spacelab payloads to be flown aboard the Shuttle, which also has been supported under NASA's Physics and Astronomy program, will be transferred beginning in FY 1994 to the Life and Microgravity Sciences and Applications program.

BASIS OF FY 1994 FUNDING REQUIREMENT

ADVANCED X-RAY ASTROPHYSICS FACILITY DEVELOPMENT

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
AXAF spacecraft.....	136,940	148,000	147,337	218,000
Instruments.....	13,800	26,000	21,000	42,300
Total.....	150,740	174,000	168,337	260,300
Mission operations and data analysis...	(3,300)	(14,900)	(14,900)	(11,600)
Upper stages.....		(8,000)	(8,000)	(16,100)

OBJECTIVES AND STATUS

The Advanced X-ray Astrophysics Facility (AXAF) will provide new observations and insights into studies of the age and evolution of the universe and its objects: the composition of the universe and its galactic and extra-galactic objects and systems; and fundamental laws of particle physics, plasma physics, and theoretical physics. X-rays, which are invisible from the Earth's surface, are produced in settings where temperatures reach millions of degrees, where particles are accelerated by gravity to nearly the speed of light, and where magnetic fields are more than a trillion times that of the Earth. X-raya are emitted as the result of highly energetic cosmic events, including stellar and galactic explosions, accretion of matter onto compact objects (such as neutron stars and black holes), and in the presence of high temperature gases. These are conditions under which the fundamental nature and relationship of energy and matter can be examined.

AXAF will allow scientists to study quasars, the most distant, luminous, and powerful objecta in the universe. AXAF, a follow-on to NASA's High Energy Astronomy Observatory (HEAO-2), the Einstein Observatory, which operated from 1978 to 1981, will allow both deeper and broader search for these objects.

AXAF will also examine the hot remnants of supernovas, explosive ends of stars' lives which will have been unobservable in other galaxiea prior to AXAF; contribute to the calculation of the mass of the universe (since x-ray emiasion of interstellar medium and stellar phenomena is not correlated with viaible emission); and study the myaterious phenomena of the x-ray burster and the diffuse x-ray background observed in the universe.

Finally, combining measurements of AXAF and of the microwave irradiance of galactic cluatera will yield a 10-fold increase in the precision of the Hubble constant. This constant is the mathematical factor used to relate the observed distance of objects from the Earth to the speed at which the universe is expanding.

AXAF uniquely combines opportunities for traditional cataloguing, study, and cosmological interpretation of astrophysical phenomena with laboratory-like examination of basic issues in theoretical physics.

1992 was a year of progress and achievement for the AXAF program. Having completed the first flight mirror pair in September 1991, as a part of the Congressionally-directed mirror demonstration program, design and development of telescope assembly and spacecraft components began in earnest. Development of science instruments and continuing mirror fabrication was performed concurrently with a reexamination of the program in 1992.

In order to improve the ability of the program to respond to future financial pressures, AXAF was restructured into two separate, specialized spacecraft. AXAF-I, a five-year mission to be launched in 1998, will focus on high-resolution imaging and low-resolution grating spectroscopy from high-Earth orbit. AXAF-S, a three-year mission to be launched a year later, will perform high-spectral resolution spectroscopy of high-energy x-ray sources from low-Earth orbit. The original AXAF was conceived as a Shuttle-serviceable, 15-year mission. Both near-term peak funding and long-term operations costs led to this restructuring.

The imaging mission (AXAF-I) will use four nested high-resolution cylindrical mirrors, reduced from the six nested pairs proposed for the original AXAF. Although this will reduce the effective imaging area of the observatory, the reduction is offset by the higher viewing efficiency of the high-Earth orbit. The imaging mission will carry two of the original AXAF instruments, the AXAF CCD Imaging Spectrometer (ACIS) and the High Resolution Camera (HRC), along with two transmission gratings. Overall, this mission will offer an observing efficiency comparable to that of the original AXAF, and retains most of the scientific capabilities, including the ability to measure the important iron line complexes at about six kiloelectronvolts. The latter is an important measure of AXAF, since iron is the most abundant of the heavy elements in the universe and is easily recognized in the x-ray spectrum.

The high-energy spectroscopy mission (AXAF-S) will carry the cryogenically-cooled X-Ray Spectrometer (XRS). A medium-size spacecraft and lower spatial resolution mirror assembly will be used to perform this narrow-band spectroscopy mission. This facility will be launched into a low-Earth orbit selected to simplify thermal control of the cryogenically-cooled instrument. The Marshall Space Flight Center will perform as the spacecraft developer for AXAF-S.

The high, elliptical orbit of AXAF-I from which observation can be performed more efficiently, combined with the dedication of separate spacecraft to AXAF's critical high-resolution imaging and narrow-band spectroscopy missions, insure that the original science goals of AXAF remain intact. AXAF-I's grazing-incidence mirrors, a nested assembly of cylindrical shapes that range from .6 to 1.2 meters in diameter, will provide a factor of two increase in effective imaging area, eight times the angular resolution, and twice the spectral range of HEAO-2.

This set of attributes, combined with advanced coatings which increase the reflectivity of the mirrors, means that AXAF-I will provide a factor of 100 increase in imaging sensitivity for point sources and that AXAF-I and -S together will reap substantial increases both in high-spatial resolution and high-spectral resolution spectroscopy compared to HEAO-2.

This budget submission assumes that AXAF-I will be launched aboard the Space Shuttle, requiring an inertial upper stage and an integral propulsion system to achieve a high elliptical orbit. NASA is currently seeking a proposal for a Titan IV/Centaur system which would be used to launch AXAF-I. This configuration will allow AXAF-I to be placed in a high circular orbit which will improve its observing efficiency. AXAF-S is to be launched aboard a Delta II launch vehicle.

CHANGES FROM FY 1993 BUDGET ESTIMATE

Congressional action reduced AXAF development funding by $7.5 million in FY 1993. This change reduced the amount of near-term financial resiliency that is available in the program, but current work on the spacecraft, instruments, and mirror assembly can remain on schedule. Funding allocations among the spacecraft and instruments reflects current planning for the restructured program.

This adjustment is partially offset by a $1.8 million increase due to the redistribution of Research Operations Support (ROS) funding.

BASIS OF FY 1994 ESTIMATE

FY 1994 constitutes the first year in which significant reductions to the AXAF funding profile will take effect. Preliminary Design Reviews (PDR) will be conducted mid-summer for AXAF-S and for AXAF-I science instruments. Critical Design Audit of the AXAF-I mirror assembly will also occur early in the year. Fabrication of the AXAF-I mirrors will continue at the Hughes-Danbury Optical Systems contractor through FY 1994, leading up to mirror coating activities which will be performed throughout FY 1995. Design of the AXAF-I optical bench and spacecraft system will occur throughout-out the year under the direction of the prime contractor (TRW, Inc.).

AXAF-S will conduct fabrication of parts and assemblies concurrently with design activities. A system-level PDR is scheduled for July 1994.

BASIS OF FY 1994 FUNDING REQUIREMENT

GRAVITY PROBE-B DEVELOPMENT

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Gravity probe-b development.....	--	--	1,900	40,000

OBJECTIVES AND STATUS

After a lengthy period of science investigation and technology demonstration. Gravity Probe-B (GP-B) is scheduled to begin development in FY 1993. Using four nearly-perfect spheres spinning at 10,000 rpm. GP-B will measure two predicted relativistic effects in the Earth's gravitational field. Although other tests have been performed of Einstein's general theory since it was developed in the early 20th century. none of these tests have provided an unambiguous verification of the theory. Having received the support of the Space Studies Board of the National Research Council since the early 1980's. GP-B is believed to provide such a test and add to the precision with which general relativistic effects are measured.

General relativity. as opposed to Einstein's special theory of relativity. addresses the effects of the gravity which emanates from large bodies of mass on the space-time continuum. The special theory was a more limited interpretation of how physical measures of space and time are distorted by the relative speeds at which objects or systems move in relationship to one another. This interpretation of experimental evidence about the constancy of the speed of light led to reinterpretations of the amount of energy resident in the physical mass of objects. The general theory extended the special theory in addressing how this distortion may produce the force of gravity.

Results of the GP-B experiment promise to affect the study and interpretation of black holes. quasars. and other astrophysical systems. More importantly. this unique experiment will test a basic theoretical interpretation of the forces of nature which is at odds with the implications of quantum mechanical theory. The GP-B experiment is thereby thought to provide a pathway to a grand unification theory of the forces of nature.

This test of the general theory requires advanced applications in superconductivity. magnetic shielding. precision manufacturing. spacecraft control mechanisms. and cryogenics. The GP-B spacecraft will employ super-precise quartz gyroscopes (small quartz spheres machined to an atomic level of smoothness); coated with a super-thin film of superconducting material (needed to be able to "read-out" changes in the direction

of spin of the gyros); encased in a ultra-low magnetic-shielded, supercooled environment (requiring a complex process of lead-shielding, a large supercooled dewar, and a sophisticated interface among the instrument's telescope, the shielded instrument probe, and the dewar); and maintained with a level of instantaneous pointing accuracy of 20 milliarcseconds (requiring precise star-tracking, a "drag free" spacecraft control system, and micro-precision thrusters).

The combination of these technologies will enable GP-B to measure (1) the distortion caused by the movement of the Earth's gravitational field as the Earth rotates west to east; and, (2) the distortion caused by the movement of the GP-B spacecraft through the Earth's gravitational field south to north, to a level of precision of .2 milliarcsecond per year, the width of a human hair observed from 50 miles.

Demonstration of many of these technologies has already been performed by Stanford University in collaboration with the Lockheed Palo Alto Research Laboratory (LPARL). Following NASA's 1984 review of the status of the GP-B experiment, NASA directed Stanford University to focus on ground test verification of GP-B technologies, augmented by the Shuttle Test of Relativity Experiment (STORE) prior to start-up of a GP-B flight program. Since then, prototype gyroscopes, telescope assemblies, a flight-like probe which surrounds the instrument and telescope, and a laboratory version of a dewar have been subjected to a first round of laboratory testing. Many subcomponent technologies have been designed and evaluated leading up to this initial verification test.

Development of prototype instrument, telescope, and dewar systems, leading to completion of ground verification testing in 1996, will continue as the program transitions to new start activities. Transition to flight article development will begin in FY 1993 following selection of a spacecraft manufacturer.

Under a unique arrangement, GP-B is to be managed by staff of Stanford University, which includes university researchers, professional managers, doctoral candidates, and other student researchers. Close technical collaboration with LPARL for GP-B probe and dewar development and testing will continue. Satellite integration will be performed by a spacecraft manufacturer to be selected under a competitive procurement sponsored by Stanford University. NASA's Marshall Space Flight Center will provide technical and managerial support of the Stanford University project and arrange for GP-B launch services and satellite operations.

CHANGES FROM FY 1993 BUDGET ESTIMATE

In accordance with Congressional direction, $27.0 million was provided for the GP-B/STORE program. $1.9 million has been provided for initiation of GP-B development in FY 1993, which will enable a spacecraft contractor selection and tests of flight gyroscopes to be conducted. The remainder has been applied to STORE activities which is budgeted in Payload and Instrument Development.

BASIS OF FY 1994 ESTIMATE

In FY 1994, GP-B design activities will begin in earnest. Following selection of a spacecraft contractor in late FY 1993, spacecraft design activities will begin. A spacecraft Preliminary Design Review (PDR) is scheduled to occur in 1995. Development of a flight unit instrument, telescope assembly, probe, and dewar will also commence, leading up to PDR's for the telescope, probe, and dewar in 1994 and 1995. Total development cost of the GP-B is estimated to be $400-440 million, excluding launch vehicle and mission operations/data analysis costs.

BASIS OF FY 1994 FUNDING REQUIREMENT

GLOBAL GEOSPACE SCIENCE

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
	(Thousands of Dollars)			
Global geospace science.....	75,300	60,100	72,647	13,300
Mission operations and data analysis...	(2,500)	(16,000)	(2,000)	(11,100)
Launch vehicles.....	(28,200)	(15,600)	(3,700)	(8,600)

OBJECTIVES AND STATUS

Global Geospace Science (GGS) is part of the United States' contribution to the International Solar Terrestrial Physics (ISTP) program. This program is an international, multi-spacecraft, collaborative science mission designed to provide the measurements necessary for a new and comprehensive understanding of the interaction between the sun and the Earth. GGS will allow the United States to become a full partner in the ISTP program, reinforcing our commitments to international cooperation and maintaining a leadership role in solar-terrestrial physics.

The GGS is a complementary science mission to the Collaborative Solar Terrestrial Research (COSTR) program under which NASA provides instruments and launch support in exchange for access to science data in a cooperative effort with the European Space Agency (ESA) and the Japanese Institute of Space and Aeronautical Science (ISAS). The combined ISTP program will include eight spacecraft: two U.S. spacecraft, Wind and Polar; five ESA spacecraft, including the Solar and Heliospheric Observatory (SOHO) and four Cluster spacecraft; and one ISAS spacecraft, Geotail. Launch of this suite of systems began in 1992 with the successful launch of Geotail and will be completed in 1995.

The GGS spacecraft will combine their measurements with the Geotail satellite and other Earth observing satellites as the first phase of the ISTP program. The two U.S. spacecraft will use a total of nineteen instruments to make simultaneous measures of the interaction of the solar wind with the Earth's magnetic field, both at the head of the field and as the field surrounds the Earth. GGS will provide the first coordinated geospace measurements of these key plasma source and storage regions, perform multi-spectral global auroral imaging, and provide multi-point study of the Earth's magnetic response to the solar wind. The GGS mission will enhance understanding of how energy and matter from the sun influences Earth's geospace and atmosphere, contributing to asaessments of the relationship of

the aun to the Earth's climate. GGS spacecraft contract award waa completed in FY 1989, aa waa final confirmation and initiation of instrument development activity. Wind instruments have completed delivery; mechanical and electrical integration is continuing. Polar instruments are scheduled for delivery in early CY 1993. Wind ia scheduled for launch in February 1994; Polar launch is scheduled for May 1994.

CHANGES FROM FY 1993 BUDGET ESTIMATE

Funding is increased by $11.8 million to support additional requirements due to schedule delays. The launch datea for the Wind and Polar missions have been revised to February 1994 for Wind and May 1994 for Polar. An additional increase of $0.7 million is due to the redistribution of Research Operations Support (ROS) funding.

BASIS OF FY 1994 ESTIMATE

FY 1994 funds will be required to complete development of the Wind and Polar spacecraft, instruments and ground syatem, and to support activities through 30 days after launch. The Wind spacecraft is scheduled for environmental testing from early 1993 through the summer. After a period of instrument refurbishment, launch preparations are to begin in December 1993.

Polar is scheduled to enter ita test program in June 1993 and to complete testing in October. Instrument refurbishment, reintegration, and retest are to precede the beginning of launch preparations in April 1994.

BASIS OF FY 1994 FUNDING REQUIREMENT

PAYLOAD AND INSTRUMENT DEVELOPMENT

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Shuttle test of relativity experiment..	27,200		25,100	2,400
Collaborative solar terrestrial research.....	62,500	50,300	50,812	25,100
Tethered satellite system.....	3,300	3,300	1,500	--
Astrophysics payloads.....	23,700	23,700	20,728	24,300
Space physics payloads.....	1,600	900	1,200	1,600
Total.....	118,300	78,200	99,340	53,400

OBJECTIVES AND STATUS

Instrument development activities support a wide range of instrumentation. Funds are included for early test, checkout, and design of instruments for long-duration free-flying missions, Shuttle-supported missions, and international flights of opportunity.

The Shuttle Test of Relativity Experiment (STORE), which will provide in orbit testing of GP-B instrument performance, will continue towards its flights aboard the Shuttle in 1995 and 1997. This Shuttle flight article will be used to demonstrate the suspension and high-rate spin properties of high-precision quartz gyroscopes in a low-gravity environment. These gyroscopes constitute the science instrument to be used in the Gravity Probe-B (GP-B) spacecraft.

The Collaborative Solar Terrestrial Research (COSTR) program, in conjunction with NASA's development of the GGS spacecraft, represents the U.S. contribution to the International Solar Terrestrial Physics (ISTP) program. Whereas the GGS program will deploy and operate two U.S. satellites, COSTR provides U.S. instruments for flight aboard foreign spacecraft. The latter include the Solar and Heliospheric Observatory (SOHO), four Cluster spacecraft provided by the European Space Agency (ESA), and the Geotail mission developed by Japan. Geotail was successfully launched in July 1992 and its operation is nominal. The European SOHO and Cluster missions are scheduled for launch in 1995.

The Tethered Satellite System (TSS) was flown aboard the shuttle in July-August 1992. The TSS science program was an international cooperative project with the Italian government. Data analysis activities related to TSS science instruments provided by the U.S. will cease after FY 1993.

Funding for Astrophysics payloads supports development of several instruments designed for flight on the Space Shuttle, including the Orbiting and Retrievable Far and Extreme Ultraviolet Spectrometer (ORFEUS) and Interstellar Medium Absorption Profile Spectrograph (IMAPS), to be flown on the German-U.S. Shuttle Pallet Satellite (SPAS, 1993); ASTRO-2 (1994), a reflight of the ultraviolet portion of the ASTRO-1 (1990) mission; and the Infrared Telescope in Space (IRTS, 1995), a joint U.S.-Japanese mission which will be launched on an expendable launch vehicle and recovered by the Shuttle.

The ORFEUS/IMAPS, which is scheduled to fly aboard the Shuttle in the summer of 1993, will explore the character of extreme and far ultraviolet sources, study the composition and distribution of matter in the neighborhood of the sun, and perform direct observations of the interstellar medium. ASTRO-2 will perform far ultraviolet spectroscopy, broad-band ultraviolet imaging and ultraviolet polarization studies of galactic and stellar phenomena. Integration and test is underway for the IRTS mission, which will survey the sky for cool galactic and intergalactic phenomena across a broad range of the infrared spectrum.

The Astrophysics program also supports a number of ongoing international and U.S. development projects. These include the High Energy Transient Experiment (HETE, 1994), a small satellite for study of gamma-ray burst phenomena in multiple wavelengths; ground-based support for Japan's Very Long Baseline Interferometry Space Observatory Program (VSOP, 1995) and Russia's RADIOASTRON (1997) program; the Stellar X-ray Polarimeter (SXRP) instrument to be flown on Russia's Spectrum-X-Gamma (SXG, 1995) mission; U.S. cooperation on the Infrared Space Observatory (ISO, 1995), a European follow-on to the Infrared Astronomical Satellite (IRAS, 1983); and portions of two instruments to be flown on Europe's X-ray Spectroscopy Mission (XMM, 1998).

The HETE is being managed by the Massachusetts Institute of Technology. As part of its innovative management activities, the university team has obtained an inexpensive satellite from industry, reduced management overhead, relied exclusively on mature technologies, and used contributions from international partners. This mission is to provide information about the precise location of gamma-ray bursters and spectral analysis of these and other high energy transient phenomena.

The VSOP and RADIOASTRON will provide the highest resolution images of radio sources ever obtained. NASA is providing scientific guidance, ground processing hardware, and construction of four ground stations (called NASA's Space Very Long Baseline Interferometer (SVLBI) subnet) to support both missions. With its extremely long baselines, VSOP and RADIOASTRON will explore very small radio sources with high angular resolution, thereby achieving higher resolution of active galactic nuclei and compact radio sources than can be achieved on the ground.

The SXRP instrument will complement other instruments on the Russian SXG mission, providing low resolution polarization data across the x-ray spectrum. Europe's ISO is an observatory with a projected life of 18 months that will provide infrared data for studies of star formation, of other infrared objects and galaxies, and of the infrared background.

The European Space Agency (ESA) XMM satellite is a medium resolution system using highly sensitive instruments providing broad-band study of the x-ray spectrum. This important mission will combine telescopes with heavily nested grazing incidence mirrors and a focal length greater than 7.5 meters with 3 imaging array instruments and two reflective grating spectrometers. The XMM is to have a design life of 10 years.

Space Physics payloads funding will be used to analyze data from instruments flown on the Atmospheric Laboratory for Applications and Science (ATLAS-1, 1992) Shuttle mission through 1993. FY 1993 Astrophysics payload funding will also be used to study this mission's results and the results of the ASTRO-1 mission. The small level of continuing funds for Space Physics payloads will be used to develop instruments for future flight opportunities.

CHANGES FROM 1993 BUDGET ESTIMATE

In accordance with Congressional direction, STORE was funded at $27 million in 1993. $1.9 million of those funds were applied to a new separate line for the start of the GP-B science program.

Also, $3.0 million was transferred from Payload and Instrument Development to Shuttle/Spacelab Mission Management and Integration for preparation for the ASTRO-2 flight in 1994. A reallocation of $0.3 million from the TSS program to Space Physics payloads was made to complete ATLAS-1 data analysis activities. In addition, $1.5 million was transferred from the TSS program to the GGS development program. These adjustments are increased by $0.5 million due to the redistribution of Research Operations Support (ROS) funding.

BASIS OF FY 1994 ESTIMATE

In FY 1994, work will continue on STORE towards its initial launch in 1995. Environmental testing of the STORE flight unit is to be performed in FY 1994.

The COSTR program will provide continuing support for development of the joint ESA-U.S. SOHO and Cluster missions. Flight model instruments for Cluster and SOHO are to be delivered during CY 1993 and integration and checkout activities will occur in Europe prior to launch in 1995.

Under Astrophysics payloads, FY 1994 funding will support data analysis of the 1993 DXS Shuttle payload mission. Support is also provided in FY 1994 for ASTRO-2 Shuttle payload development and conduct of science activities for the 1994 mission. Preparation for the Japanese IRTS mission, which will be returned by the Shuttle in 1995, will also be underway.

Payloads for other U.S. and international missions scheduled to be under development in FY 1994 include the HETE and SXG misaions, both scheduled for launch in FY 1995. Support will alao be provided in FY 1994 for the ISO mission and for ongoing preparation for the Japanese and Russian radio astronomy missions. Early component design and fabrication will continue for the XMM misaion.

BASIS OF FY 1994 FUNDING REQUIREMENT

EXPLORER DEVELOPMENT

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Extreme ultraviolet explorer.....	6.600	--	--	--
Explorer platform.....	11,350	--	--	--
X-ray timing explorer.....	47,400	65,100	65.651	45,600
Advanced composition explorer.....	--	--	--	28,000
Small explorers.....	33,654	35.000	36,397	39,400
Other explorers.....	10,096	12,400	13,784	10,300
Total.....	109,100	112,500	115,832	123,300

OBJECTIVES AND STATUS

Past Explorers have discovered radiation trapped within the Earth's magnetic field. investigated the solar wind and its interaction with the Earth. studied upper atmosphere dynamics and chemistry. mapped our galaxy in radio waves and gamma-rays. and determined properties of the interstellar medium through ultraviolet observations. Explorers have performed active plasma experiments on the magnetosphere. made in-situ measurements of the comet Giacobini-Zinner. and completed the first high-sensitivity. all-sky survey in the infrared. discovering over 300.000 sources.

Recent missions include the 1992 launch of Extreme Ultraviolet Explorer (EUVE) and the first Small Explorer mission. the SAMPEX.

The X-ray Timing Explorer (XTE. 1996) and two Small Explorer missions are currently under development. The latter are the Fast Auroral Snapshot Explorer (FAST. 1994) and the Submillimeter Wave Astronomy Satellite (SWAS. 1995).

The XTE will use three instruments to conduct timing studies of x-ray sources. An comprehensive record of the source of x-rays with varying intensity over time. characterization of those attributes. and study of compact x-ray emitting objects such as binary stellar masses will be performed by XTE. FAST will provide high resolution data on the Earth's aurora and how electrical and magnetic forces control them. The flow of electrons. protons. and other ions will be studied with greater sensitivity and spatial discrimination and

faster sampling than ever before, using five small instruments. FAST data will be integrated with the results of other Earth observing satellites and ground observations. SWAS will provide discrete spectral data for study of the water, molecular oxygen, and carbon monoxide in dense interstellar clouds, the presence of which is related to the stability of these clouds.

The Advanced Composition Explorer (ACE, 1997) will initiate development in FY 1994. This space physics mission will use nine instruments to study the composition of the solar corona, interplanetary and interstellar media, and galactic matter across a wide range of plasma phenomena. The instruments include six high-resolution spectrometers, designed to improve the collecting power of previous systems, to study the mass and charge of plasma phenomena. Three other instruments will provide measures of the lower energy phenomena related to the solar wind.

NASA's Explorer program also provided telescope mirrors and instrument components for the Japanese Astro-D mission. Astro-D, which was successfully launched on February 19, 1993, will observe x-rays from cosmic sources with emphasis on moderate-resolution imaging and broad-band spectroscopy.

The mid-sized Far Ultraviolet Spectroscopic Explorer (FUSE, 2000) mission is still in the stage of conceptualization.

A second Announcement of Opportunity (AO) for Small Explorer missions was released by NASA in September 1992. Of the 60 proposals received, NASA plans to select three or four in June 1993 for further definition. By May 1994, it is expected that two or three missions will be confirmed for development leading to launches in 1997 through 1998.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The XTE mission was decreased by $1.7 million to provide support required by other Explorer programs, consistent with the integrated management philosophy of the Explorer program. Mission definition activities for FUSE received a portion of these funds, with the remainder applied to Small Explorers. The amount was offset by a $2.2 million increase to XTE, a $0.9 million increase to Small Explorers, and a $0.2 million increase to Other Explorers due to the redistribution of Research Operations Support (ROS) funding.

BASIS OF FY 1994 ESTIMATE

Development activities on the XTE mission will continue in preparation for launch in 1996. Following Critical Design Review (CDR) which will occur in spring 1993, instruments and spacecraft components will be integrated onto the observatory throughout 1994.

The ACE will transition from mission definition to development in FY 1994. Initial design and fabrication of instruments and spacecraft subsystems will commence, leading to a CDR scheduled for late FY 1994.

Development activities, including integration, test and launch preparation for the FAST and SWAS missions will continue in FY 1994 in preparation for launches in 1994 and 1995, respectively.

BASIS OF FY 1994 FUNDING REQUIREMENT

MISSION OPERATIONS AND DATA ANALYSIS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
AXAF mission operations and data analysis	3,300	14,900	14,900	11,600
Hubble space telescope operations and servicing	207,700	214,200	216,676	222,200
Hubble space telescope data analysis	36,000	42,300	42,357	38,500
Astrophysics mission operations and data analysis	85,300	100,500	88,268	84,500
Space physics mission operations and data analysis	42,900	69,000	53,184	59,400
Total	375,200	440,900	415,385	416,200

OBJECTIVES AND STATUS

Funds provided to NASA in this program are used to conduct NASA satellite operations and distribute funds among science participants in NASA flight programs for the analysis of satellite data and the conduct of ongoing theory and research programs. Funding is also applied to pre-flight preparations for NASA satellite operations and data analysis activities, and for long-term data archiving and data base services. NASA's MO&DA program supports satellite operations during the performance of the core missions of NASA satellites, extended operations of selected spacecraft, and for ongoing analysis of data after the usable life of spacecraft has expired. In addition, funds from this category are used to support ongoing servicing support for the Hubble Space Telescope (HST).

Pre-launch operations funding for the Advanced X-ray Astrophysics Facility (AXAF) program is to support the development of a ground control system and science center and preparation for flight system operation. A common ground system located at Marshall Space Flight Center will be used to serve the combined requirements for the Space Shuttle, Spacelab, and AXAF flight operations. Both AXAF missions will be supported by a single AXAF Science Center.

Hubble Space Telescope (HST) science operations are carried out through an independent HST Science Institute, which operates under a long-term contract with NASA. Satellite operations, including telemetry, flight operations, and initial science data transcription, is performed on-sight at Goddard Space Flight Center under separate contract. While NASA retains operational responsibility for the observatory, the Science Institute plans, manages, and schedules the scientific operations of the HST. In a single year of operations, the activities of over 500 scientists are supported under the HST program, and over 15,000 observations recorded.

In order to extend its operational life and provide a basis for future enhancements of its scientific capabilities, HST is designed to be serviceable. This requires on-orbit maintenance and changeout of spacecraft subsystems and scientific instruments every few years. In December 1993, the first HST servicing mission is to be performed. This mission will restore the faint object and crowded field capabilities of the telescope which have been unavailable due to spherical aberration of the primary mirror. Also, jitter induced by thermal effects on the observatories solar arrays will be corrected by the installation of two modified solar arrays provided by the European Space Agency. Several subsystems, including system gyroscopes and a data processing system, will be installed so as to restore redundancy and to insure operations until the next servicing mission occurs. Funds are used each year to provide planning and development of instruments for future servicing missions and for development of other components thought to be critical to the reliability of HST. Ongoing modification and upkeep of system ground operations is also performed.

Other satellites developed wholly or in part by NASA are also supported under the Astrophysics and Space Physics mission operations and data analysis programs. Currently, five operational missions in astrophysics and seven operational missions in space physics are supported. Astrophysics missions include the Compton Gamma-Ray Observatory (CGRO, 1991), the Extreme Ultraviolet Explorer (EUVE, 1992), the International Ultraviolet Explorer (IUE, 1978), the Cosmic Background Explorer (COBE, 1989), and U.S. participation in the international Roentgen Satellite (ROSAT, 1990). Space physics missions include the Voyager 1 and 2 (1977), Ulysses (1990), Pioneer 10 and 11 (1972, 1973), Geotail (1992), the SAMPEX (1992), the Japanese cooperative satellite YOHKOH (1991), and the Interplanetary Monitoring Platform (IMP, 1973).

The Compton Observatory measures gamma-rays, which are produced by the most energetic and exotic fundamental physical processes occurring in nature. Instruments on this mission provide unique information on phenomena occurring in quasars, active galaxies, black holes, neutron stars, supernova, and the nature of the mysterious cosmic gamma-ray bursts.

EUVE is studying the sky at wavelengths once believed to be completely absorbed by the thin gas between the stars. Observations at these wavelengths hold the key to understanding the hottest stars in our galaxy and to mapping a "local bubble" of hot and transparent gas in the vicinity of the sun. An all-sky survey lasting six months is completed, and detailed spectroscopic investigation of specific objects is underway.

Early in its operation, the satellite discovered "flares" or explosive events on the surface of at least one extreme ultraviolet star and, despite the obscuring gas, has surprised many by observing sources outside our galaxy.

Space Physics research activities rely on data received from a number of operational spacecraft. The Interplanetary Monitoring Platform (IMP) provides the only measure of solar wind input to the Earth. The Yohkoh spacecraft, a cooperative program with the Japanese, is continuing to gather x-ray and spectroscopic data on solar flares, irradiance, and oscillations. Ulysses is on its way to study the sun's polar regions, measuring the interplanetary medium and solar wind as a function of heliographic latitude, having been swung out of the plane of the ecliptic by the gravity of Jupiter. Voyager 1 and 2 and Pioneer 10 and 11 are continuing to look for the heliospheric boundary with interstellar space as they travel beyond the planets. The SAMPEX is measuring the composition of solar energetic particles, anomalous cosmic rays, and galactic cosmic rays. Geotail, a Japanese spacecraft which is the first part of the cooperative International Solar Terrestrial Physics (ISTP) program, is studying the Earth's magnetotail.

Support for future missions is also included under the Physics and Astronomy MO&DA program, including U.S.-developed and launched satellites, payloads orbited under the Shuttle/Spacelab program, and U.S. participation in international programs.

CHANGES FROM FY 1993 BUDGET ESTIMATE

A $12.6 million reduction was applied to astrophysics satellite operations and data analysis as part of the $20 million Congressional general reduction. The main impact was a major reduction in support to university researchers.

The $7.4 million reduction to space physics programs resulted in earlier-than-planned termination of International Cometary Explorer (ICE) routine operations, and Dynamics Explorer (DE) and Active Magnetospheric Particle Trace Explorer (AMPTE) data analysis. Funding for participation in various international mission activities was also eliminated. Another $8.8 million was transferred from Space Physics MO&DA to GGS Development due to launch schedule changes in that program.

These adjustments are partially offset by a $2.6 million increase to HST operations, servicing, and data analysis; and a $0.8 million increase to Astrophysics and Space Physics MO&DA due to the redistribution of Research Operations Support (ROS) funding.

BASIS OF FY 1994 ESTIMATE

FY 1994 will support ongoing operation of NASA spacecraft; data analysis for current and previously operational satellites; support for astrophysics data archiving, data management, and theory programs; and development of ground systems and science operations for future spacecraft. Future servicing needs of the HST are also supported.

The AXAF MO&DA funds will support the ongoing development of unique ground system elements of the AXAF program and documentation of ground control operations. Preliminary Design Review of AXAF mission operations will be held mid-year, supported by preliminary reviews of off-line ground system software, a ground system simulator, and the AXAF Science Center; and Critical Design Review of the on-line ground data system.

FY 1994 funds for the HST will support the first servicing mission, continue preparations for future servicing missions, support ongoing development of ground systems and ground system operations, and conduct mission operations and data analysis for the Hubble system. Preparation for flight, including conduct of the Flight Readiness Review for the first servicing mission and final integration of HST servicing equipment with the Shuttle, flight operations for the mission, and ground operations during and after servicing are all to be performed in early FY 1994. Limited interruption of science operations is planned while initial calibration and test of the new HST configuration is performed. HST operations and servicing funds will also support development of the Near Infrared Camera (NIC) and Space Telescope Imaging Spectrograph (STIS) instruments to be flown on future servicing missions, and ongoing development and maintenance of HST components and subsystems needed to perform future telescope maintenance. As ongoing ground and science operation of the telescope is performed, changes to flight system software and ground system software, hardware, and operations protocols will continue.

HST data analysis funds will support the completion of a data archiving system; continuance of the activities of the Guaranteed Time Observers program, composed of science instrument teams and designated observatory scientists; and expansion of the Guest Observer and Archival Researchers programs.

In FY 1994, Astrophysics MO&DA will fund operation and data analysis activities for the CGRO, EUVE, IUE, COBE, and ROSAT astrophysics missions. Funds are also provided for the continuation of support for the Japanese Astro-D mission and for initiation of operations of the High Energy Transient Experiment (HETE).

Space Physics MO&DA will support the operation and data analysis for the Voyager, Ulysses, Pioneer, Geotail, SAMPEX, Yohkoh, and IMP space physics missions. Support for the GGS mission is included in FY 1994 for the initiation of Wind and Polar operations.

The remainder of Astrophysics MO&DA funds will support data archiving, dissemination, and theory programs. Data analysis and archiving activities will continue for the High Energy Astrophysics Observatories (HEAO) which ceased operation in 1981 and the Infrared Astronomical Satellite (IRAS) which ceased operation in 1983. The recently-established Astrophysics Data System and other archiving systems will also continue to provide scientific users access to NASA's astrophysics data. Astrophysics MO&DA funds also support theoretical research of topics broader than those typically supported under Research and Analysis funding.

BASIS OF FY 1994 FUNDING REQUIREMENT

RESEARCH AND ANALYSIS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
	(Thousands of Dollars)			
Space physics supporting research and technology	36,237	43,400	37,257	37,800
Astrophysics supporting research and technology	33,700	38,000	34,301	34,400
Total	69,937	81,400	71,558	72,200

OBJECTIVES AND STATUS

The objectives of the Supporting Research and Technology (SR&T) program funded under Research and Analysis are to: (1) optimize the design of future missions through science definition, development of advanced instruments and concepts, and definition of proposed new missions; (2) strengthen the technological base for sensor and instrument development; (3) enhance the value of current space missions by carrying out ground-based observations and laboratory experiments; (4) conduct the basic research necessary to understand astrophysics phenomena and solar-terrestrial relationships and develop theories to explain observed phenomena and predict new ones; and, (5) continue the acquisition, analysis and evaluation of data from laboratories, airborne observatories, balloons, rocket and spacecraft activities.

Astrophysics program activities in the areas of gamma-ray, x-ray, ultraviolet, visible light, infrared, submillimeter, and radio astrophysics are supported with these funds. Space Physics researchers in the disciplines of magnetospheric, ionospheric, cosmic ray, and solar physics are also supported.

In Astrophysics, both the Explorer and Great Observatories programs rely upon accomplishments of the SR&T program for technology development and instrument design to achieve planned science objectives. Current emphasis is being placed on studies of advanced instruments and detectors with increased sensitivity and resolution.

Space physics research and analysis is a broadly structured effort to enhance our understanding of the characteristics and behavior of plasmas in the solar corona, the interplanetary medium and in the vicinity of the Earth and other planets. Recent thrust is directed at studies of the near-Earth geospace

environment, from the flow of the solar wind past the magnetosphere to variations of the plasma environment near the surface of the Earth. These studies have many practical implications, such as determining disruptive effects on communications, analyzing the impact of solar input on the global circulation of the Earth's upper atmosphere, or examining space plasma effects on spacecraft.

In addition to supporting basic and experimental astrophysics research for future flight missions, the SR&T program develops and promotes United States scientific and technological expertise. The SR&T program carries out its objectives through providing grants to universities, nonprofit and industrial research institutions, and funds to scientists at NASA Centers and other government agencies. Several hundred grants are awarded each year to the community of scientists. These grants help train future investigators in astrophysics and space science disciplines -- science and engineering graduate and post graduate students who will become the Nation's future scientific leaders.

NASA also allocates SR&T funds to Advanced Technology Development (ATD) programs. ATD is used to develop new mission concepts and to ensure that the technology for a mission is mature before development begins in order to minimize cost, schedule, and technical risks. Mission concept and definition studies are used to identify and define new and usable technologies and optimize their use within an affordable development cost. Increasing emphasis is being made within the Agency to better utilize advanced technologies in future missions.

The Astrophysics ATD program will continue to support definition studies for the Stratospheric Observatory for Infrared Astronomy (SOFIA), an airborne-observatory intended to replace the current NASA airborne astronomy system, and early studies of space infrared technologies. All other mission definition studies have been eliminated.

Space Physics SR&T activities include continuing definition studies of the Thermosphere, Ionosphere, Mesosphere Energetic and Dynamics (TIMED) mission and the High Energy Solar Physics (HESP) mission.

CHANGES FROM FY 1993 BUDGET ESTIMATE

Research and Analysis program funding has been reduced by a total of $11.0 million, consistent with Congressional direction. As a result, some ongoing activities have been terminated, and no new activities have been initiated this fiscal year. This reduction is offset by a $1.2 million increase due to the redistribution of Research Operations Support (ROS) funding.

BASIS OF FY 1994 ESTIMATE

During FY 1994, the Astrophysics and Space Physics R&A program will continue to support its activities at approximately the same level as FY 1993, including the continuation of support for mission concept studies for the SOFIA, TIMED, and MESP candidate missions.

BASIS OF FY 1994 FUNDING REQUIREMENT

SUBORBITAL PROGRAM

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Airborne science and applications.....	12,000	12,600	13,014	13,600
Balloon program.....	13,900	15,400	15,437	16,400
Sounding rockets.....	34,200	37,300	36,392	39,500
Total.....	60,100	65,300	64,843	69,500

OBJECTIVES AND STATUS

The suborbital program uses aircraft, balloons, and sounding rockets to conduct versatile, relatively low-cost research of the Earth's ionosphere and magnetosphere, space plasma physics, stellar astronomy, solar astronomy, and high energy astrophysics. Activities are conducted on both a national and international cooperative basis.

Research with instrumented jet aircraft has been an integral part of the NASA Physics and Astronomy program since 1965. Quick response to "targets of opportunity" is able to be conducted at relatively low cost. The airborne science and applications program operates the Kuiper Airborne Observatory (KAO) for astronomy research.

The KAO facility consists of a C-141 aircraft equipped with a 91-centimeter infrared telescope. The C-141's ability to fly for several hours at altitudes approaching 13 kilometers allows cloud-free astronomical observations to be made. This altitude also allows for infrared observations, which are not absorbed by atmospheric water vapor at this altitude. This has been essential in expanding astronomical observations into the infrared region of the electromagnetic spectrum from one micrometer to hundreds of micrometers.

In FY 1992, the C-141 conducted one major campaign in the Southern Hemisphere to continue studies of the Supernova SN1987A, the nearest visible supernova to occur in modern times, and observations of the galactic center. The KAO is currently the only facility in the world that can conduct these observations in the far infrared and submillimeter wavelengths. Infrared observation of Mars, Pluto, and Jupiter also continue to provide important scientific return.

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The Balloon program provides a cost-effective means to test flight instrumentation in the space radiation environment and to make observations at altitudes which are above most of the water vapor in the atmosphere. In many instances it is necessary to fly primary scientific experiments on balloons, because of size, weight, or cost considerations or lack of other opportunities.

Balloon experimentation is particularly useful when studying infrared, gamma-ray, and cosmic-ray astronomy. In addition to the level-of-effort science observations program, significant emphasis has been and will be placed on development of a balloon capable of lifting more than 3,500 pounds. In addition, the balloon program is now capable of conducting a limited number of missions lasting several days; successful long-duration flights have been conducted in the Antarctic, and more are planned.

A major objective of the sounding rocket program is to support a coordinated research effort. Sounding rockets are uniquely suited for performing low altitude measurements (between balloon and spacecraft altitude) and for measuring vertical variations of many atmospheric parameters. Special areas of study supported by the sounding rocket program include the nature, characteristics, and composition of the magnetosphere and near space; the effects of incoming energetic particles and solar radiation on the magnetosphere, including the production of aurora and the coupling of energy into the atmosphere; and the nature, characteristics, and spectra of radiation of the sun, stars and other celestial objects.

In addition, the sounding rocket program provides several science disciplines with the means for flight testing of instruments and experiments being developed for future flight missions. The program also provides a means for calibrating flight instruments and obtaining vertical atmospheric profiles to complement data obtained from orbiting spacecraft.

Support for Spartan missions aboard the Shuttle is also included. Spartan 201 consists of a 17-inch diameter solar telescope with an ultraviolet coronagraph and a white light coronagraph to observe and measure the solar source of the solar wind. Spartan 201 is planned for Shuttle launch in 1993, with reflight in 1994 and 1995 to provide correlative data for the Ulysses mission during its passage over the solar poles.

CHANGES FROM FY 1993 BUDGET ESTIMATE

$1.5 million was transferred from the sounding rocket program to the GGS development program. In addition, a $1.0 million increase occurred due to the redistribution of Research Operations Support (ROS) funding.

BASIS OF FY 1994 ESTIMATE

In FY 1994, the Airborne Science and Applications funding will be used to continue flight missions utilizing the capabilities of the KAO.

Balloon program funding is required for purchase of balloons, helium, launch services, tracking and recovery as well as for maintenance and operations of the National Scientific Balloon Facility (NSBF) at Palestine, Texas, and other remote launch sites. Funding for the experiments flown on balloons is provided from research and technology funds which support the various scientific disciplines. Balloon program funding will continue to support up to 40 missions per year.

FY 1994 funds will also provide for the vehicles, hardware, integration, launch site maintenance, etc. to assure continuation of the sounding rocket and Spartan programs. Funding will continue to support up to 40 rocket flights per year. The Spartan program will support the planned reflights of Spartan 201.

BASIS OF FY 1994 FUNDING REQUIREMENT

INFORMATION SYSTEMS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Information systems.....	--	--	--	26.500

OBJECTIVES AND STATUS

Beginning in FY 1994, support for NASA's Information Systems program will be divided between the Mission to Planet Earth program and the Physics and Astronomy program. Physics and Astronomy will support three of the four areas of application, development, and research in advanced computing applications: science data management and archiving, science networking, and information systems research and analysis. Multiple science disciplines will be supported by the projects funded under this program.

NASA's National Space Science Data Center (NSSDC) archives and distributes data acquired in space flight programs. A master directory service for distribution of science data to a wide range of users is also maintained. In addition, support is provided for development of search techniques to access data from multiple data bases and to assimilate data from multiple data sets into single applications.

The NASA Science Internet is a computer networking service used to provide research access to flight program data bases, data processing systems, and to applications for scientific collaboration. Researchers and organizations participating in NASA-funded flight programs and in joint international missions are supported by this capability. This capability continues to expand in response to increased requests for access, and is closely coordinated with other U.S. computer networking facilities.

Funds provided for information system research and technology is used to improve science data management, analysis, and visualization techniques to improve scientists' productivity. A NASA Research Announcement is to be released in 1993 for continuing investigation in these areas.

BASIS OF FY 1994 ESTIMATE

Beginning in FY 1994, Physics and Astronomy funding for the Information Systems program will support the continued operation of the NSSDC to distribute science data assets. Development of master directory services and data exchange standards for enhanced inter-operability among distributed and heterogeneous data bases will be emphasized. Science data networking needs will be improved with the NASA Science Internet, allowing more users access to the network consistent with flight program requirements.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1994 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE

PLANETARY EXPLORATION

SUMMARY OF RESOURCES REQUIREMENTS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate	Page Number
		(Thousands of Dollars)			
Mars observer	85,000	--	--	--	RD 4-1
Mars balloon relay	1,200	--	--	--	
Mars '94	--	--	3,500	3,500	RD 4-7
Cassini development	210,700	210,000	204,953	266,600	RD 4-9
Mission operations and data analysis	160,721	170,300	163,482	160,700	RD 4-12
Research and analysis	76,600	106,900	101,680	126,400	RD 4-15
Total	534,221	487,200	473,615	557,200	
Distribution of Program Amount by Installation					
Johnson Space Center	12,900	13,700	13,700	14,100	
Marshall Space Flight Center	800	1,000	1,000	1,200	
Goddard Space Flight Center	11,900	23,600	24,575	30,300	
Jet Propulsion Laboratory	399,521	320,700	311,400	367,300	
Ames Research Center	17,100	10,400	10,647	22,400	
Langley Research Center	650	700	713	800	
Headquarters	91,350	117,100	111,580	121,100	
Total	534,221	487,200	473,615	557,200	

OFFICE OF SPACE SCIENCE

PLANETARY EXPLORATION

OBJECTIVES AND JUSTIFICATION

The Planetary Exploration program encompasses the scientific exploration of the solar system including the planets and their satellites, comets and asteroids, and the interplanetary medium. The program objectives are: (1) to determine the nature of planets, comets, and asteroids as a means for understanding the origin and evolution of the solar system; (2) to understand the Earth better through comparative studies with the other planets; (3) to understand how the appearance of life in the solar system is related to the chemical history of the solar system; and, (4) to provide a scientific basis for the future use of resources available in near-Earth space. Projects undertaken in the past have been highly successful based on a strategy that places a balanced emphasis on the Earth-like inner planets, the giant gaseous outer planets, and the smaller bodies (comets and asteroids). Missions to previously unexplored solar system bodies typically start at the level of reconnaissance to achieve a fundamental characterization of the bodies. Subsequent missions then conduct more detailed studies.

With the Magellan mapping of the Venusian terrain, the reconnaissance phase of inner planetary exploration, which began in the 1960's, is virtually complete. Through the Magellan and Pioneer-Venus missions, we have now obtained a basic characterization of Venus' atmosphere as well as fundamental data about the formation of the planet. Magellan, which was launched in April 1989, arrived at Venus in August 1990 and began providing global maps of the cloud-shrouded surface of Venus, including its land forms and geological features. Using a Synthetic Aperture Radar (SAR) to penetrate the planet's opaque atmosphere, Magellan provides a resolution sufficient to identify small-scale topographical features that address fundamental questions about the origin and evolution of the planet. Magellan has successfully mapped 99 percent of the surface of Venus. Radar and altimetry data acquisition are also completed. The spacecraft is currently obtaining gravity data to accurately determine the planet's gravity field and the internal stresses and density variations so that the evolutionary history of Venus can be compared with that of Earth. Mission operations are planned for termination in May 1993.

Mars has been a primary program focus due to its potential for previous biological activity and as a site for future human missions. The Viking landings in 1976 carried the exploration of Mars forward to a high level of scientific and technological achievement, thereby setting the stage for the next step of detailed study, the geologic and climatological mapping of the planet by Mars Observer, launched in September 1992. New insights into the Martian system are anticipated when the spacecraft arrives at Mars in August 1993. Mars Observer will build upon the earlier discoveries of the Mariner-9 and Viking missions with emphasis on the geologic and climatic evolution of this complex planet. The Mars Observer spacecraft will also support

mission operations for Mars '94, a Russian mission with international cooperation. French-supplied electronics aboard the Mars Observer will relay data from the landers and balloons to be carried by the Russian Mars '94 mission. Funding is also provided in FY 1993 and FY 1994 to provide up to two U.S. instruments for flight aboard the two landers which will fly on the Russian Mars '94 mission as well.

While studies of the inner solar system were initiated in the early 1960's, reconnaissance of the giant outer planets began more recently. The Pioneer-10 and -11 missions to Jupiter in 1973 and 1974 were followed by the Voyager-1 and -2 spacecraft encounters in 1979. Voyager-1 then encountered Saturn in November 1980, with Voyager-2 following in August 1981. The Voyager data on these planets, their satellites, and their rings revolutionized concepts about the formation and evolution of our solar system. Voyager-2 flew by Uranus in January 1986, providing our first close look at this giant outer planet. Its trajectory carried it to an encounter with Neptune in August 1989, which provided spectacular images of this mysterious planet and its satellites. In February 1990, Voyager-1 took the first composite photograph of our solar system. Detailed studies of outer solar system bodies will commence with Galileo.

Galileo was launched in October 1989. In October 1991, the spacecraft flew by Gaspra, obtaining the first detailed images ever obtained of an asteroid. Additional images were played back when Galileo again flew close to Earth in December 1992. In August 1993, the spacecraft will return images of Ida, a second asteroid, en route to Jupiter. Upon arrival at Jupiter in December 1995, the comprehensive science payload will extend our knowledge of the Jovian system well beyond the profound discoveries of the Voyager and Pioneer missions. During twenty-two months of operation, Galileo will inject an instrumented probe into Jupiter's atmosphere to make in-situ measurements while the orbiter will have the capability to make as many as ten close encounters with the Galilean satellites. Failure to fully deploy the High Gain Antenna (HGA) will require the mission to be conducted using only the Low Gain Antenna (LGA) for spacecraft telemetry and data down link. Planning is currently underway to determine the changes in mission design and Deep Space Network (DSN) coverage to support the new mission requirements.

Cassini will continue our detailed studies of the outer solar system by conducting extensive investigations of Saturn and its satellites. In conjunction with spacecraft observations, the European Space Agency (ESA)-provided Huygens Probe will conduct in-situ atmospheric measurements of Saturn's moon Titan. Building upon the discoveries made through the Pioneer and Voyager missions, Cassini will provide new understanding into the origin of the solar system and will help determine whether the necessary building blocks for the chemical evolution of life exist elsewhere in the universe. In an effort to reduce total program costs and improve mass and schedule margins, the program has been restructured. Despite significant changes to the spacecraft design, the science payload remains essentially intact. All technical and programmatic changes have now been approved, and development activities are underway with no change in the planned launch in October 1997 aboard a Titan IV launch vehicle. En route to Saturn, the spacecraft will fly by Earth, Venus, and Jupiter to gain sufficient acceleration to reach Saturn in June 2004. Upon arrival, the spacecraft will conduct extensive investigations of the Saturnian system for four years.

In addition to the development of new missions, ongoing Mission Operations and Data Analysis (MO&DA) activities are a major focus of the Planetary Exploration program. Extensive effort continues in support of the Voyager-Neptune, Galileo, Magellan, and Mars Observer missions. Activities include the monitoring of spacecraft operations, ongoing mission design and software development, and acquisition/processing/analysis of new data as it is acquired. Ongoing data analysis of existing data sets are also conducted. Planetary flight support activities provide continuous design, development and maintenance of ground support hardware and software for mission control, telemetry and command functions for all planetary spacecraft still in operation.

The Research and Analysis (R&A) program continues to define the scientific priorities for future missions as well as maximizing the exploitation of existing data sets. Advanced program activities provide planning and preparation for the systematic exploration of the solar system on a scientifically and technically sound basis. The instrument definition program ensures maximum scientific return from future missions by the definition and development of state-of-the-art scientific instrumentation. The Mars Data Analysis program continues to support analysis of data obtained by Viking and earlier missions so that we are scientifically prepared for the next phase of Mars exploration. Establishment of a Planetary Data System (PDS), which will permit the archiving of these and all other data products in a manner promoting and facilitating their use, is also supported. The High Resolution Microwave Survey (HRMS) program uses radio astronomy facilities and Deep Space Network (DSN) antennas to analyze microwave signals in space for technological evidence of intelligent life beyond our solar system. The Exobiology program has been transferred from Life Sciences to Planetary R&A beginning in FY 1994 to more accurately reflect the nature of the research conducted. Exobiology research is directed toward understanding the origin and distribution of life, and life-related molecules on Earth and throughout the universe.

BASIS OF FY 1994 FUNDING REQUIREMENT

MARS OBSERVER DEVELOPMENT

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Spacecraft	42,700	--	--	--
Experiments	36,000	--	--	--
Ground operations	6,300	--	--	--
Total	85,000	--	--	--
Mars balloon relay experiment	1,200	--	--	--
Mission operations and data analysis	--	(45,600)	(40,526)	(34,300)
Launch vehicle	(32,600)			
Upper stage	(6,800)	(200)		

OBJECTIVES AND STATUS

The objectives of the Mars Observer mission are to extend and complement the data acquired by the Mariner and Viking missions by mapping the global surface composition, atmospheric structure and circulation, topography, gravity and magnetic fields of Mars. The mission will also determine the presence of volatile chemical constituents in the atmosphere and soil and observe their interaction with the Martian environment during all four seasons of the Martian year.

Mars Observer was launched in September 1992 on a Titan III/Transfer Orbit Stage (TOS) launch vehicle. The spacecraft is currently en route to Mars and will arrive in August 1993. Operations to date have been nominal. All cruise deployments as well as initial spacecraft and science instrument checkouts are now completed. Upon arrival, the spacecraft will be inserted into a near-polar Martian orbit from which it will carry out geochemical, geophysical, and climatological mapping of the planet over a period of approximately one Martian year, which is nearly two Earth-years. The Mars Balloon Relay (MBR) experiment will permit a significant increase in the amount of data returned from the landed stations of the Russian Mars '94 mission. Using French-supplied electronics carried aboard the Mars Observer spacecraft, MBR data will be incorporated into the Mars Observer Camera (MOC) data stream for transmission to Earth. MBR operations will be initiated near the conclusion of the Mars Observer nominal mission in 1995.

FY 1993 activities will be focused on concluding the checkout of all flight hardware and science instruments before arrival at Mars and establishment of the final mapping orbit. Also, flight software updates and ground data system implementation for transition from cruise to prime mission operations in FY 1994 will be accomplished. Plans for science data archiving and the disposition of flight spare hardware are also underway.

BASIS OF FY 1994 FUNDING REQUIREMENT

MARS '94

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thouaands of Dollars)		
Mars '94.....	--	--	3,500	3,500

OBJECTIVES AND STATUS

The Mars '94 mission is a Russian mission comprised of an orbiter and two soft landers which will be deployed on the Martian surface. Each lander will carry a variety of science instruments provided by several international partners including Germany, Finland and France. These include descent and surface imagery, in-situ seismology and meteorology measurements. In addition to the Mars Observer/MBR support, this funding augments U.S. participation in the mission by providing instruments for flight aboard the landers.

The original arrangement was for the Russians to expand their original launch configuration from two landers to three, with the U.S. to provide two instruments for flight aboard the third lander. To avoid significant hardware redesigns, the Russians subsequently decided not to fly a third lander. However, U.S. participation in the mission is still planned. The current plan is for the U.S. to provide two soil oxidation instruments, one for flight aboard each of the two original landers. To conserve mass, power, and space, these experiments will share common electronics subsystems with German and Russian instruments. The U.S. instruments will determine the presence of atmospheric and/or soil oxidants which theoretically caused the rapid destruction of the organic material tested on the Viking mission. The instruments will be shipped to Helsinki, Finland in late 1993 for integration into the total science payload complement. The scheduled launch date is November 1994 aboard a Russian Proton launch vehicle. The U.S. will be given access to all science data from the Mars '94 mission within one year. U.S. scientists are also involved on nearly all other science instruments as well.

CHANGES FROM FY 1993 BUDGET ESTIMATE

No funds were originally requested for this initiative in the FY 1993 budget since initial planning was not conducted until last July-August. Funding has been reallocated from Mars Observer mission operations and Voyager-Neptune data analysis, in accordance with NASA's initial FY 1993 operating plan. FY 1993 funds will support detailed design and fabrication activities in coordination with international partners.

BASIS OF FY 1994 ESTIMATE

FY 1994 funds will support final integration and testing of the two U.S. science instruments. These instruments will be delivered to Helsinki, Finland in November 1993 for electrical integration with the rest of the science payload. After initial testing, the payload will then be shipped to Russia in December 1993 for final integration and testing with the Russian spacecraft.

BASIS OF FY 1994 FUNDING REQUIREMENT

CASSINI DEVELOPMENT

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Spacecraft	134,000	122,700	122,700	168,500
Experiments	68,500	76,800	76,800	81,500
Ground operations	8,200	10,500	5,453	16,600
Total	210,700	210,000	204,953	266,600
Launch vehicle	(20,100)	(9,300)	(5,278)	(82,300)

OBJECTIVES AND STATUS

During the 1970's, our Nation established scientific and technological leadership in exploration of the outer solar system with successful launches of Pioneers 10 and 11 and Voyagers 1 and 2. The Cassini mission will maintain our leadership in solar system exploration. Building upon the earlier discoveries of Pioneer and Voyager, Cassini's study of the Saturnian system will greatly improve our understanding of the early evolutionary processes which formed our entire solar system. The Cassini targets (asteroids, Titan, and Saturn system) have a common origin in the outer solar system. The icy conditions on these bodies preserve a record of different stages and processes occurring during solar system formation and evolution. Analysis of their structure and composition may help determine whether the necessary building blocks for the chemical evolution of life exist elsewhere in the universe. In conjunction with Galileo's study of the Jovian system, the mission should also provide much insight as to how and why the large, gaseous outer planets have evolved much differently than the inner solar system bodies.

Cassini is scheduled for launch in October 1997 aboard a Titan IV launch vehicle. An extensive cruise period is required to reach Saturn, requiring the spacecraft to fly by Venus, Earth, and Jupiter to gain sufficient velocity to reach its destination. Upon arrival in June 2004, the spacecraft will begin four years of study of the Saturnian system which will provide intensive, long-term observations of Saturn's atmosphere, rings, magnetic field, and moons. In conjunction with the observations conducted by the spacecraft, the ESA-provided Huygens Probe will be injected into the atmosphere of Saturn's moon Titan, to conduct in-situ physical and chemical analyses of its methane-rich, nitrogen atmosphere which is a possible model for the pre-biotic stage of the Earth's atmosphere. The Cassini spacecraft will also obtain a radar map of most of Titan's surface.

In an effort to reduce total program costs, mass and power requirements, an extensive restructuring exercise was conducted in 1992. These objectives were achieved without significantly impacting the spacecraft design or deleting any of the science instruments. Major mass savings were achieved by deleting spacecraft instrument booms in favor of instrument pallets mounted directly onto the spacecraft structure. Onboard propellant tanks were reduced in size to meet Cassini-unique requirements since the tanks were originally sized to accommodate Comet Rendezvous/Asteroid Flyby (CRAF) requirements as well. These measures will not only reduce total spacecraft mass by approximately 1,400 kg (> 3,000 lbs), but reduce peak power and thermal control requirements as well. Significant cost savings will be achieved by reductions in spacecraft test hardware in favor of a protoflight approach in which the flight model structure will be used for all integrated test activities. Additional savings are achieved by reducing spare hardware and reverting to class B parts wherever possible on both the spacecraft and instruments. Consistent with these changes, the Jet Propulsion Laboratory (JPL) is also committed to reducing total workforce requirements by reducing contractor oversight, delegating authority to lower-level managers, and reduced hardware fabrication and test requirements due to the new protoflight approach.

The restructured program has now been approved by NASA management, and implementation of the proposed changes is well underway. A system-level Critical Design Review (CDR) was completed in December 1992, and fabrication of the redesigned hardware is being initiated. Revised management approaches are being undertaken to streamline requirements and delegate authority to lower-level managers. Project personnel have been consolidated at JPL to optimize communications and expedite administrative functions.

Total program costs are further reduced by transferring the Advanced Multimission Operations System (AMMOS) development from Cassini to the Planetary Mission Operations and Data Analysis (MO&DA) budget. The AMMOS activity will develop ground system software which provides an integrated picture of the status of spacecraft systems, thereby reducing the workforce levels required for mission operations. Although originally funded as a Cassini-unique requirement, development of this capability will benefit other future planetary missions as well. These combined actions have reduced total development costs by approximately $300 million, with the majority of savings achieved in the FY 1994-FY 1995 time frame. The October 1997 launch date remains unchanged.

CHANGES FROM FY 1993 BUDGET ESTIMATE

$5.6 million was transferred from Cassini to the Planetary MO&DA (Flight Project Support) budget, in accordance with the FY 1993 initial operating plan. These funds support the AMMOS ground system upgrade which is no longer funded as a Cassini-unique activity. Funding is increased by a $0.5 million reallocation of Research Operations Support (ROS) funding.

BASIS OF FY 1994 ESTIMATE

FY 1994 funding supports the continuation of detailed design activities for the majority of spacecraft subsystems. CDRs are planned for the Radio Frequency Subsystem (RFS), Low Gain Antenna (LGA), Attitude and Articulation Control System (AACS), and a joint CDR will be held with Germany for the propulsion system. Concurrently, most spacecraft subsystem elements will begin initial hardware fabrication and integration.

Similar activities will be conducted for the science payload. All remaining CDRs will be completed by mid-FY 1994, and hardware fabrication will be initiated. Fabrication of engineering models (EM) for the two U.S.-provided Huygens Probe instruments will be completed and delivered to ESA by mid-FY 1994. The probe Hardware Design Review (HDR) will also be conducted in early FY 1994. Preliminary Design Reviews (PDRs) and CDRs are scheduled for all major elements of the ground system, culminating with a system-level CDR in late 1994. Funding also will be provided to the Department of Energy (DOE) for their ongoing Radioisotope Thermoelectric Generator (RTG) development activities in support of the Cassini mission. A Preliminary Safety Analysis Review (PSAR) of this system is also planned for 1994.

BASIS OF FY 1994 FUNDING REQUIREMENT

MISSION OPERATIONS AND DATA ANALYSIS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Galileo operations	57,700	63,000	59,429	57,600
Magellan operations	45,100	7,000	7,000	5,100
Mars observer operations	--	45,600	40,526	34,300
Pioneer programs	10,600	--	--	--
Voyager-Neptune data analysis	4,300	6,000	5,010	5,700
Planetary flight support	43,021	48,700	51,517	58,000
Total	160,721	170,300	163,482	160,700

OBJECTIVES AND STATUS

The objectives of the planetary Mission Operations and Data Analysis (MO&DA) program are in-flight operation of planetary spacecraft as well as the acquisition and analysis of data from these missions. The planetary flight support activities are those associated with the design and development of planetary ground operation systems for multiple missions, and other activities that support the mission control, tracking, telemetry, and command functions through the Deep Space Network (DSN) for all planetary spacecraft.

Operations for Galileo began in October 1989 for the spacecraft's 6-year journey to Jupiter. The spacecraft passed by Earth last December for the second and last time as it departed the inner solar system. Since launch, the spacecraft has returned the first detailed images ever obtained of an asteroid -- Gaspra. Galileo will encounter a second asteroid, Ida, in August 1993. Failure to deploy the High Gain Antenna (HGA) requires a rebaselining of the mission for use of the Low Gain Antenna (LGA) only. Planning is underway to determine changes in mission design and DSN coverage to support the new mission requirements.

The Magellan spacecraft was launched in May 1989. Since its arrival at Venus in August 1990, the spacecraft's radar has mapped approximately 99 percent of the planet's surface to a ground resolution of about 150 meters. Although mapping activities are complete, mission operations continue through May 1993 as the spacecraft obtains detailed gravity measurements which, when studied in coordination with radar mapping data, will help determine the internal geological processes responsible for much of the planet's topography. Extensive data processing and analysis of existing radar data sets are underway as well.

Data analysis from the Voyager-2 Neptune encounter of August 1989 continues. This flyby of Neptune provided our first detailed images of this distant planet, as well as previously unknown moons and geyser-like surface eruptions.

Mars Observer mission operations began in October 1992 when the spacecraft was launched aboard a Titan III with a Transfer Orbit Stage (TOS) upper stage. The spacecraft will arrive at Mars in August 1993 for a two-year prime mission, followed by support of the Russian Mars '94 mission through early FY 1996.

Pioneer mission operations funding and responsibility was transferred to Physics and Astronomy MO&DA beginning in FY 1993, and is ongoing.

Planetary flight support provides ground system development and support for all planetary missions. Efforts are underway in FY 1993 to initiate the Advanced Multimission Operations System (AMMOS). This ground system upgrade will improve our ability to monitor spacecraft systems, and is designed to reduce workforce levels and increase operations efficiencies for Cassini and other future planetary missions.

CHANGES FROM FY 1993 BUDGET ESTIMATE

Total MO&DA has been reduced by $6.9 million due to the Congressionally-directed general reduction of $9.0 million, the reallocation of $3.5 million to support the Mars '94 mission, and the transfer of $5.6 million for the AMMOS activities from Cassini development to Planetary Flight Support. Funding reductions have been accommodated by reducing program flexibility in Galileo and Mars Observer operations, Voyager-Neptune data analysis and Planetary Flight Support activities. The $5.6 million AMMOS transfer initiates development of ground system upgrades which will improve operating efficiencies for future planetary missions, starting with the Cassini mission. Total funding is increased by $0.1 million due to the reallocation of Research Operations Support (ROS) funding.

BASIS OF FY 1994 ESTIMATE

Mission operations, ground system and flight software development activities for Galileo will continue in support of probe release in July 1995 and arrival at Jupiter in December 1995. Failure to deploy the HGA will also require significant changes to mission planning and flight software development activities to accommodate transition to a LGA mission.

Mars Observer prime mission operations will begin in early FY 1994 and will continue through FY 1995 and beyond. Funding will support mission operations and engineering teams which monitor the spacecraft and develop command uplink software for mapping activities. Funds will also support the acquisition and processing of science data as well as the science team data analysis activities.

Magellan mission operations are scheduled for termination in FY 1993. FY 1994 funding for Magellan supports continued science investigations and analysis of existing data sets only. Ongoing support for the Voyager-Neptune data analysis program will continue.

Planetary Flight Support funding supports the development of ground system capabilities required for Galileo and Mars Observer prime mission operations. Additional ground system development will continue in preparation for the Cassini launch in October 1997. Development of the AMMOS ground system upgrade will also continue with further software development and testing activities leading to operational capability in time for Cassini and subsequent planetary missions.

BASIS OF FY 1994 FUNDING REQUIREMENT

RESEARCH AND ANALYSIS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Supporting research and technology.....	69,500	81,500	59,160	87,600
Advanced programs.....	7,100	25,400	30,433	16,000
Toward other planetary systems (TOPS)..	--	--	12,087	12,300
Exobiology.....	(9,384)	(9,400)	(9,230)	10,500
Total.....	76,600	106,900	101,680	126,400

OBJECTIVES AND STATUS

The Research and Analysis (R&A) program consists of three elements to: (1) assure that data from flight missions is fully exploited: (2) undertake complementary laboratory and theoretical efforts; and (3) define science rationale and develop required technology to undertake future planetary missions.

Supporting Research and Technology (SR&T) funds provide resources for basic and applied research activities across a wide variety of planetary science disciplines. Planetary astronomy includes all observations made by ground-based telescopes of solar system bodies, with emphasis on outer planets, comets, and asteroids. The data acquired is used both for basic research in support of planetary program objectives and for direct support of specific flight missions. Funding also supports continued operation of the Infrared Telescope Facility (IRTF) in Hawaii. Planetary atmospheric research studies the properties of other planetary atmospheres which can aid us in better understanding our own weather and climate. Observations of the atmospheres of Venus, Jupiter, Saturn, Uranus, and Neptune acquired by Pioneer Venus and Voysger, have laid the basic observational groundwork for major advances in this field.

Planetary geology/geophysics activities include the study of surface processes, structure, and history of solar system bodies. Comparative studies provide a fundamental understanding of the physical processes which control the development and evolution of all planetary bodies, including the Earth. In this respect, data from the Magellan mission is of crucial importance. Planetary materials/geochemistry activities study the chemistry, composition, age, and physical properties of solid material in the solar system through the

study of returned lunar samples, meteorites, and extraterrestrial dust grains. These continue to yield new information about the history of our solar system. This program is coordinated with the lunar sample and meteorite research, which is supported by other agencies, such as the National Science Foundation (NSF). The operation of the Lunar Curatorial Facility is also supported by this activity.

Instrument definition activities provide maximum scientific return from future missions by the definition and development of state-of-the-art scientific instrumentation. The Mars Data Analysis program continues to support analysis of data obtained by Viking and earlier missions so that we are scientifically prepared for the next phase of Mars exploration. Establishment of a Planetary Data System (PDS) which will permit the archiving of these and all other data products in a manner promoting and facilitating their use, is also supported.

Advanced programs funding supports the planning and preparation of future planetary missions to ensure technical feasibility, scientific viability and consistency with the overall strategic planning and scientific objectives of the Planetary Exploration program.

Technology developed as part of the Search for Extraterrestrial Intelligence (SETI) program has been incorporated into the Towards Other Planetary Systems (TOPS) program and is funded within the R&A budget as the High Resolution Microwave Survey (HRMS). The program uses radio astronomy facilities and Deep Space Network (DSN) antennas to analyze microwave signals in space for technological evidence of intelligent life beyond our solar system.

Exobiology uses space and ground-based opportunities to study the cosmic evolution of biogenic compounds, prebiotic evolution, and the evolution of primitive and advanced life forms. The program examines these processes in the environments in which they occurred, including Earth, the planets of our solar system and elsewhere in the universe. Research is based on data from a wide variety of science disciplines such as planetary astronomy, geology, chemistry, and atmospheres. Additional areas of research include astrophysics, paleontology, and advanced development of flight experiments for Earth and planetary spacecraft. Theoretical models developed from analysis of existing data and laboratory investigations increase our understanding of early chemical and biological events that support the origin and evolution of life on Earth and elsewhere in the universe. This activity is transferred from Life Sciences beginning in FY 1994 to more accurately reflect the nature of the research conducted by the program.

CHANGES FROM FY 1993 BUDGET ESTIMATE

FY 1993 funding is reduced by $6.5 million due to a Congressionally-directed general reduction. Congress also directed the funding of the HRMS program ($12.0 million) and an increase of $5.0 million in Advanced programs for the NEAR and MESUR Pathfinder missions to be absorbed from existing R&A funds, which required a $23.5 million reduction to SR&T and Mars data analysis. The Agency's initial operating plan indicated

plans for use of $2.5 million from Advanced programs for acquisition of the Russian Mars '94 Lander engineering model to seek possible technology benefits for use in future NASA small missions. Plans for this activity are on hold pending further negotiation. These reductions are partially offset by a $1.3 million reallocation of Research Operations Support (ROS) funding.

BASIS OF FY 1994 ESTIMATE

During FY 1994, basic and applied research efforts will continue in all science disciplines. Funding will also support the upgrading of ground-based laboratories to reduce maintenance costs and improve capabilities. Instrument definition activities will continue to support development of new state-of-the-art instruments for future missions. Advanced programs support will continue to conduct future mission studies in support of the Discovery program as well as future Cassini-class missions to the outer solar system. The Mars Data Analysis program will support continued analysis of Mars data in preparation for new Mars missions, and development of the Planetary Data System to archive all planetary data for enhanced accessibility for all users will continue.

FY 1994 funds will continue to support the TOPS/HRMS program. Development of a Sky Survey operational system is underway with planned completion in 1996. Observations will continue in the interim via use of the prototype system fielded in FY 1993 at Arecibo, Puerto Rico and Goldstone, California. The Targeted Search system, currently operational, will be upgraded to full capability for its deployment to Australia in FY 1994.

The Exobiology program has also been transferred from Life Sciences to Planetary R&A beginning in FY 1994 to more accurately reflect the nature of the research conducted by the program. Research is directed toward understanding the origin and distribution of life, and life-related molecules on Earth and throughout the universe. The Exobiology program will emphasize the development of new flight experiment concepts which can validate theoretical models of solar system evolution and mechanisms for the synthesis of biologically significant molecules in space.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1994 ESTIMATES

BUDGET SUMMARY

OFFICE OF LIFE AND MICROGRAVITY SCIENCES AND APPLICATIONS

SUMMARY OF RESOURCES REQUIREMENTS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate	Page Number
		(Thousands of Dollars)			
Life sciences					
Research and analysis.....	50,700	55,600	53,940	49,200	RD 5-5
Flight experiments.....	94,700	89,700	81,089	94,700	RD 5-8
Centrifuge facility.....	(7,724)	18,400	5,521	--	RD 5-10
Search for extraterrestrial intelligence	12,250	13,500	--	--	RD 5-13
Subtotal, life sciences	157,650	177,200	140,550	143,900	
Microgravity science research					
Research and analysis.....	(16,600)	(17,500)	(17,870)	18,400	RD 5-14
Flight experiments.....	(104,200)	(177,800)	(155,064)	71,000	RD 5-15
Shuttle/spacelab payload, mission management and integration.....	(78,000)	(101,100)	(94,018)	117,700	RD 5-17
Subtotal, transferred programs	(198;800)	(296,400)	(266,952)	207,100	
Total.....	157,650	177,200	140,550	351,000	

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1994 ESTIMATES

BUDGET SUMMARY

OFFICE OF LIFE AND MICROGRAVITY SCIENCES AND APPLICATIONS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Distribution of Program Amount by Installation				
Johnson Space Center	63,500	68,457	59,500	118,884
Marshall Space Flight Center	--	--	--	89,360
Kennedy Space Center	5,700	6,342	4,900	24,758
Goddard Space Flight Center	300	723	200	300
Jet Propulaion Laboratory	700	1,501	600	10,182
Ames Research Center	63,050	65,133	45,850	31,700
Langley Research Center	800	1,112	600	2,200
Stennis Space Center	100	56	--	--
Lewis Research Center	200	--	100	36,800
Headquarters	23,300	33,876	28,800	36,816
Total	157,650	177,200	140,550	351,000

OFFICE OF LIFE AND MICROGRAVITY SCIENCES AND APPLICATIONS

LIFE AND MICROGRAVITY SCIENCES AND APPLICATIONS PROGRAM

OBJECTIVES AND JUSTIFICATION

Beginning in FY 1994, NASA's in-space research program for life science and microgravity research has been consolidated in order to best take advantage of flight opportunities available with the Shuttle/Spacelab program, as well as those presented through the international community. Toward this objective, all Shuttle/Spacelab science activities have been consolidated into the Life and Microgravity Science program. The elements included are the Life Sciences program, the Microgravity Research program, and the Shuttle/Spacelab Mission Management and Integration program. This consolidation was made to further optimize the joint science utilization of the Shuttle/Spacelab system, and with it, increase program synergy. This grouping will help focus attention on potential scientific, management, and programmatic overlaps in program objectives, and will streamline the utilization of the extensive Shuttle/Spacelab infrastructure.

The goal of the Life Sciences program is to conduct basic and applied biomedical and biological research which seeks to understand the role of gravity on living systems. Results from the research program are applied to maintaining astronaut health and productivity; understanding the response of biological mechanisms to weightlessness; study of basic cellular, developmental and physiological processes; and development of environmental health requirements and support systems for long-term piloted space flight. In FY 1993, the Life Sciences program is expanding its cooperation with the National Institutes of Health (NIH), with the objective of increasing participation of the mainstream biomedical community in the program. NIH Initiative activities include a wide range of ground-based and space flight research opportunities which span both the flight and the research and analysis programs.

The Life Sciences Flight Experiments program, consisting of Shuttle/Spacelab flight experiments program and other international cooperative efforts, selects, defines, develops, and conducts in-space medical and biological research. The flight experiments program is actively preparing experiments for launch on two Spacelab missions in 1993. Definition and development activities are underway to develop payloads for later Spacelab missions, including a joint program with Russia which is aimed at understanding biomedical problems associated with long-duration missions. As part of Shuttle/Spacelab experiments, the Extended Duration Orbiter Medical Program (EDOMP) is continuing its work to develop specific medical countermeasures for the extension of Shuttle flights to 16 days. The flight program involves important collaborative activities with other U.S. agencies, including the NIH and the National Science Foundation, and with the European Space Agency (ESA) and the space agencies of France, Germany, Japan and Russia.

The Life Sciences Research and Analysis program includes seven major elements: (1) Space Physiology & Countermeasures, (2) Human Factors, (3) Environmental Health, (4) Space Radiation Health, (5) Controlled Ecological Life Support Systems (CELSS), (6) Space Biology, and (7) Operational Medicine. The Research and Analysis program also includes the following additional activities: data archiving; NASA Specialized Centers of Research and Training (NSCORTs); NIH Initiative activities; and Cosmos/Mir cooperation.

Funding and management responsibility for the Search for Extraterrestrial Intelligence (SETI) program, previously budgeted within Life Sciences, has been deleted. Technology developed under this program has been incorporated in the Towards Other Planetary Systems (TOPS) program within the Planetary Exploration Research and Analysis program, in accordance with Congressional direction. In addition, the Exobiology program, previously budgeted within Life Sciences, has been transferred to Planetary Exploration to better reflect the nature of the research conducted in the program. No changes in program content or funding have been made.

The Microgravity Research program uses the unique attributes of the space environment to conduct research in three primary areas: 1) Fluid Physics, which includes the study of the behavior of fluids and transport phenomena, condensed matter physics, and combustion science; 2) Materials Science, which includes electronic and photonic materials, metals and alloys, glasses and ceramics; and 3) Biotechnology, which focuses on macromolecular crystal growth and mechanical environmental influence on cell science. Goals of the program include developing a comprehensive approach of basic and applied research in these primary areas. It is aimed at utilizing the low gravity environment to obtain new knowledge and understanding of those physical phenomena made obscure by the effects of gravity and to increase understanding of gravity-dependent phenomena. This understanding will add significantly to the basis of a reliable predictive capability for processing operations and technology issues in both Earth and non-Earth environments.

The Microgravity Research and Analysis program supports ground-based research and definition studies for flight experiment candidates in areas such as solidification and crystal growth, fluids and combustion research, gravitational physics, critical point phenomena and processing of biological materials. Ground-based research includes laboratories, drop-tubes, drop towers, and aircraft.

The Microgravity Research program provides a range of experimental capabilities. The program currently supports a wide variety of hardware development, such as unique flight experiments necessary to conduct benchmark research and modular, multi-user research facilities which will be the cornerstone of microgravity science and applications research in the future. Experiments will be principally flown on the Shuttle, Spacelab, and/or other commercially-developed spacecraft.

The Materials Processing in Space program has been renamed the Microgravity Science Research program in accordance with the 1992 National Research Council's recommendation.

BASIS OF FY 1994 FUNDING REQUIREMENT

LIFE SCIENCES RESEARCH AND ANALYSIS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Life sciences research and analysis.....	50,700	55,600	53,940	49,200

OBJECTIVES AND STATUS

The Research and Analysis activity supports Space Life Sciences program goals of advancing knowledge in all areas of space life sciences and developing medical and biological systems which enable human habitation in space. The objectives of the program are to support basic and applied studies which prepare for flight investigations on the Shuttle and Space Station; to use ground based models to simulate and study weightlessness and other aspects of space flight; to perform analysis of data from previous space flights; and to develop procedures and techniques in support of manned space flight, such as environmental standards and monitoring equipment. The program is composed of seven elements: (1) Space Physiology & Countermeasures, (2) Human Factors, (3) Environmental Health, (4) Radiation Health, (5) Controlled Ecological Life Support Systems (CELSS), (6) Space Biology, and (7) Operational Medicine. The research and analysis program also includes the following additional activities: Data Archiving; NASA Specialized Centers of Research and Training (NSCORTs); NIH Initiative activities; and Cosmos/Mir cooperation.

The Space Physiology and Countermeasures program focuses on the study of chronic physiological problems associated with extended duration in space, while the Human Factors program works on solutions to psycho-social challenges for crew members in isolated high-risk environments. The goal of the Environmental Health program is to assess environmental risk by developing a toxicology database and contamination modeling capacity, determining spacecraft maximum allowable concentration limits, and developing new technologies for environmental monitoring. The Radiation Health program is working towards establishing the scientific basis for the radiation protection of humans engaged in space. The CELSS program seeks to provide air, water, and food to support life through a combined physical-chemical-bioregenerative closed system which could receive only energy from the external environment. The Space Biology program explores the role of gravity in life processes and uses gravity variations as an environmental tool to investigate fundamental biological questions. The Operational Medicine program provides medical support to all manned missions and explores the role of gravity in life processes and uses gravity variations as an environmental tool to investigations, develops an estimate of medical risks associated with advanced missions with humans, and establishes biomedical countermeasures and life support research priorities.

Exobiology research is directed toward understanding the origin and distribution of life, and life-related molecules, on Earth and throughout the universe. Beginning in FY 1994, this program will be transferred to Planetary Exploration Research and Analysis, in order to more accurately reflect the nature of the program's research activities.

Data archiving activities strive to develop an operational database for archiving results of the NASA Life Sciences Research program for dissemination in a readily accessible form to the life sciences community nationwide and, eventually, internationally. The NIH Initiative activities within the research and analysis program supports grants to individual researchers and research teams as well as data archiving and secondary data analysis activities. Cooperation with the NIH will also lead to the development of new NASA Specialized Centers of Research and Training (e.g. with the National Institute on Deafness and Other Communication Disorders), the development of a new program of NASA supplements to ongoing NIH grants, and joint activities with the National Library of Medicine concerning bibliographic databases and flight data archiving.

The NSCORT program serves to advance basic knowledge and generate effective strategies for solving problems in focused research areas. In FY 1993, the sixth and seventh NSCORT will be established, one for integrated physiology and the other, in cooperation with the NIH, for vestibular research. Overall, the Life Sciences NSCORTs will conduct research in the following science programs: space biology, environmental health, space radiation health, controlled ecological life support systems, integrated physiology and vestibular research. Ultimately, the life sciences NSCORT program will expand to a total of nine participating institutions.

Research activities on Mir study the effects of long duration space flight on Cosmonauts by doing pre-flight and post-flight biomedical evaluations (e.g. bone densiometry). Activities associated with the FY 1993 Cosmos biosatellite include experiment development, support of flight activities, and post-flight data analysis.

CHANGES FROM FY 1993 BUDGET ESTIMATE

Overall funding for the Research and Analysis program has been decreased by $1.7 million. This reflects the Congressionally-directed reduction of $4.0 million; an additional $2.2 million reduction as part of the directed $20.0 million life sciences general reduction; the transfer of the $1.6 million biospheric research program to Space Applications (Earth Science Research and Analysis) to consolidate funding and program management responsibility; and the addition of $5.2 million for NIH cooperative activities. These program adjustments are partially offset by a $0.9 million increase due to the redistribution of Research Operations Support (ROS) funding.

BASIS OF FY 1994 ESTIMATE

Basic research activities will continue to use Earth-based models to simulate the effects of weightlessness and other components of the space flight environment, and provide for extended data analysis and supporting studies so that investigators can learn as much as possible from data collected in space. These studies will further refine our understanding of how microgravity can be used to investigate questions of medical and basic biological importance on Earth such as blood pressure control, maintenance of bone and muscle mass, vestibular function and the regulation of balance, cell metabolism and division, etc.

The Environmental Health program will develop and refine environmental standards in areas such as microbiology and toxicology; these standards will be key to developing safe and cost-effective life support and environmental monitoring systems. The Radiation Health program will continue to operationally monitor radiation exposure of Shuttle crews, refine dose estimates and study the biological effects (especially the increased risk of cancer) of space radiation exposure. Further, the Space Human Factors program will use remote, harsh and isolated environments such as the polar regions to develop standards for psychological selection, test and develop new training procedures, and design new systems that use state-of-the-art knowledge of human operations with complex automated systems.

The CELSS program will continue to investigate biological and physical-chemical methods to control the interior environment of piloted spacecraft. In addition to ongoing research in biomass production and waste management systems, near-term emphasis will be on development of laboratory scale models and definition of man-rated systems for proof of design concepts.

The Research and Analysis programs will continue to develop joint activities with the NIH, as discussed in a following separate section.

BASIS OF FY 1994 FUNDING REQUIREMENT

LIFE SCIENCES FLIGHT EXPERIMENTS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Flight experiments.....	94,700	89,700	81,089	94,700

OBJECTIVES AND STATUS:

The objective of the Life Sciences Flight Experiments program is to develop and utilize payloads designed to expand the understanding of the basic physiological mechanisms involved in adaptation to the space environment. The program includes selection, definition, in-flight operation, data analysis and reporting on medical and biological investigations involving humans, animals, and plants. The program's flight experiments lead to a better understanding of gravitational adaptation, enhance our basic science knowledge and increase the confidence with which we can estimate the physiological consequences of longer exposure to the space environment.

In FY 1993, preparations in the Shuttle/Spacelab Flight Experiments program are underway to support several Shuttle/Spacelab missions. Among these are the SL-D2 cooperative mission with Germany and the second dedicated life sciences mission, Spacelab Life Sciences-2 (SLS-2). The Spacelab-D2 life sciences experiments will focus on cardiovascular physiology and fluids systems. The SLS-2 experiments will focus on cardiovascular, metabolic, musculoskeletal and neurovestibular functions and gather additional data for the Extended Duration Orbiter Medical Program (EDOMP). As part of the Flight Experiments program, EDOMP is continuing its work to develop specific medical countermeasures for the extension of Shuttle flights to 16 days. In FY 1993, nine animal and plant experiments will also be flown as Shuttle secondary payloads.

Efforts in the Flight Experiments program also continue on definition and development of new experiments and hardware planned to be flown on the third and fourth dedicated life sciences missions (SLS-3 and -4), the 1995 cooperative Mir mission with Russia and in future orbiter middeck areas. SLS-4 participation will be dedicated to brain and behavioral research, and will be the first Spacelab with major NIH involvement, serving as the main NASA contribution to the Decade of the Brain. The cooperative mission series with Russia will involve three elements: a Shuttle mission on which a Cosmonaut is a crew member (STS-60); a mission on which one astronaut will stay aboard the Russian Mir Space Station; and a Shuttle docking mission of the Shuttle/Spacelab with the Mir. This program will provide the opportunity for both countries to understand each other's methods and approaches to long-term human physiologic adaptation to space flight, as

well as provide the U.S. with its first long-duration mission information since the Skylab program. Continuation of previous NASA collaboration with the former Soviet Union in its COSMOS biosatellite program is planned, with joint research on one COSMOS flight in FY 1993.

CHANGES FROM FY 1993 BUDGET ESTIMATE

An overall reduction of $10.6 million in the Flight Experiments program is the result of several actions. A $21.7 million reduction has been applied to the ongoing Flight Experiments program as a result of FY 1993 appropriations action. Partially offsetting this reduction are program additions of $2.0 million to fund requirements for the 1995 Shuttle-Mir rendezvous mission; $4.8 million for cooperative activities with NIH as directed by Congress, (the remaining $5.2 million of NIH funding is included within the Research and Analysis program); and $6.3 million due to the redistribution of ROS funding.

BASIS OF FY 1994 ESTIMATE

During FY 1994, specific studies within the Life Science Flight Experiment program will focus on the feasibility of extending crew stay times aboard the Space Shuttle. Key activities include the requirements and technology development for operational medicine, radiation protection and environmental health; countermeasure development and testing; human factors engineering; and life support systems testing and monitoring. Cooperation with the NIH will result in secondary payload flight opportunities in FY 1994 focused on developmental biology, cell biology and physiology. As in the past, continued medical support and monitoring of crew health will be provided for each of the Space Shuttle missions flown in FY 1994.

Towards these objectives, a major activity in FY 1994 will involve preparations for the three-mission series of U.S./Russia cooperative research. Post-flight analysis of the data received from experiments aboard STS-60, the initial segment of the cooperative program, will continue. Hardware development, testing, integration and delivery of experiments and equipment planned for flight aboard the Mir and the Shuttle for the Mir docking mission will continue toward their 1995 flights. Astronaut and cosmonaut crew training is under way at both the Russian and Johnson Space Center sites. Experiment integration for the docking mission will begin in late summer, 1994.

Preparations will continue in support of the 1994 IML-2 Spacelab mission, with experiments being completed and readied for integration. Significant analysis will continue on the results of the late FY 1993 SLS-2 mission. Funds are also included in support of the continuing cooperative relationship with NIH, discussed in a following, separate section.

Funds are not included in the FY 1994 estimate for Space Station and related activities. The requirements definition, design and development of hardware and experiments for the Space Station are being reevaluated consistent with the Agency's reexamination of its plans for development of the Space Station. A revised program plan consistent with the redesign proposal selected will be submitted to the Congress at a later date.

BASIS OF FY 1994 FUNDING REQUIREMENT

CENTRIFUGE FACILITY

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Centrifuge facility.....	(7,724)	18,400	5,521	--

OBJECTIVES AND STATUS

The Centrifuge Facility is designed to conduct on-orbit operations of a 0 to 2g specimen support capability for long-term research on Space Station Freedom (SSF). The Centrifuge Facility will accommodate the requirements of a wide variety of biological investigations using animals, plants, cells and tissue cultures, and will improve understanding of gravity's role in living organisms' functions and development. This facility represents a marked enhancement of basic research capability to the Life Sciences program, and has been a top priority recommendation of the National Academy of Sciences for several years. Development of the facility was planned to begin in FY 1993, with contract award expected in the third quarter.

CHANGES FROM FY 1993 BUDGET ESTIMATE

Funding for the Centrifuge facility has been reduced by $12.9 million. This change reflects the reduction of $10 million specifically directed by Congress and an additional $3.1 million as part of a Life Sciences general reduction directed by Congress. These adjustments are offset by a $0.2 million increase due to the redistribution of ROS funding.

BASIS OF FY 1994 ESTIMATE

No funds have been included in the FY 1994 request for the currently-planned Centrifuge Facility. The funding plans are being reevaluated consistent with the Agency's reexamination of its plans for the Space Station. A request for funds to continue development of the centrifuge will be deferred subject to the Space Station redesign plans and revised schedule.

BASIS OF FY 1994 FUNDING REQUIREMENT

NATIONAL INSTITUTES OF HEALTH INITIATIVE

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Research & analysis.....	--	--	(5,200)	(5,200)
Flight program.....	--	--	(4,800)	(4,800)
Total.....	--	--	(10,000)	(10,000)

OBJECTIVES AND STATUS

The objective of the NASA/National Institutes of Health (NIH) Initiative is to expand participation of the mainstream biomedical community in the NASA Life Sciences program. The most effective way to expand this participation is to collaborate with and through the NIH. The joint research programs will seek to involve the best researchers and institutions in space life sciences research opportunities by providing supplements to ongoing NIH grants, funding of joint research centers at universities and medical schools, and soliciting and funding new individual grants. Cooperation with the NIH will also lead to the development of new NASA Specialized Centers of Research and Training (NSCORTs), the development of a new program of NASA supplements to ongoing NIH grants, NIH use of unique NASA facilities, (e.g. the Vestibular Research Facility and Biocomputation Center at Ames Research Center), as well as joint activities with the National Library of Medicine concerning bibliographic databases and flight data archiving. NASA will have the lead in joint space flight research activities; NIH will lead in joint ground-based research activities.

The scope of joint flight activities include Shuttle middeck locker flight opportunities beginning in late FY 1993 (e.g. Physiological and Anatomical Rodent Experiments (PARE)) and additional opportunities on future missions such as those utilizing the Spacelab, and potentially, non-U.S. space platforms such as Mir and Biocosmos. The SLS-4 participation will be dedicated to brain and behavioral research, and will be the first Spacelab with major NIH involvement, including funding for investigators. In addition, SLS-4, planned for a 1998 flight, will be the main NASA contribution to the Decade of the Brain.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The NIH Initiative funding of $10.0 million has been applied to both the Flight Experiments program ($4.8 million) and the Research and Analysis program ($5.2 million).

BASIS OF FY 1994 ESTIMATE

Cooperation with the NIH will result in secondary payload flight opportunities in FY 1994 focused on developmental biology, cell biology and physiology. Within the Research and Analysis program, joint activities will continue to be developed so that U.S. capabilities can be most efficiently used to maintain the health of people on Earth and in space, and will include supplements to ongoing NIH grants, funding of joint research centers, and soliciting and funding new individual grants.

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BASIS OF FY 1994 FUNDING REQUIREMENT

SEARCH FOR EXTRATERRESTRIAL INTELLIGENCE

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Search for extraterrestrial intelligence.....	12,250	13,500	--	--

OBJECTIVES AND STATUS

The Search for Extraterrestrial Intelligence (SETI) program has been deleted from the Space Life Science program. Technology developed under this program has been incorporated in the Towards Other Planetary Systems (TOPS) program in the Planetary Exploration Research and Analysis program, in accordance with Congressional direction.

CHANGES FROM FY 1993 BUDGET ESTIMATE

Per Congressional direction, funding has been terminated for SETI within the Life Sciences program.

BASIS OF FY 1994 FUNDING REQUIREMENT

MICROGRAVITY SCIENCE RESEARCH AND ANALYSIS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
	(Thousands of Dollars)			
Research and analysis.....	(16.600)	(17.500)	(17.870)	18.400

OBJECTIVES AND STATUS

The research and analysis activity provides the scientific foundation for all current and future projects. Ground-based research leads to space investigations with potential for future applications. This activity also provides analytical support and technology development for future ground and space capabilities. Most research projects are a result of proposals from the scientific community stemming from NASA research announcements, and are extensively reviewed by peer groups prior to selection and funding.

CHANGES FROM FY 1993 BUDGET ESTIMATE

FY 1993 funding is increased by $0.4 million due to the redistribution of ROS funding.

BASIS OF FY 1994 ESTIMATE

Ground-based research and analysis will continue in FY 1994 in the areas of benchmark science, materials science, and biotechnology. Research objectives include definition of the role of gravity-driven influences in a variety of processes. A series of solicitations (NASA Research Announcements and Announcements of Opportunity) will be released to focus and expand the science community involvement. This will allow for the development of strong candidates for future flight opportunities.

BASIS OF FY 1994 FUNDING REQUIREMENT

MICROGRAVITY SCIENCE FLIGHT EXPERIMENTS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Flight experiments.....	(104,200)	(177,800)	(155,064)	71,000

OBJECTIVES AND STATUS

During FY 1992 the first United States Microgravity Laboratory (USML-1), the first United States Microgravity Payload (USMP-1), the first International Microgravity Laboratory (IML-1), and Spacelab-Japan all flew with outstanding experimental results.

The Flight Experiments program provides hardware for experiments for a wide range of opportunities. NASA currently supports the development of Shuttle middeck, Spacelab, and cargo-bay experiments. This policy maximizes the effective use of the Shuttle by developing hardware to meet scientific and technical requirements. Long-term program plans assume the availability of a Space Station or other long-term platform as a major element for conducting microgravity research, consistent with the strategy for evolution of microgravity experiments from short to long duration periods of on-orbit operations. Current activities also include participation in the joint U.S.-Russian Spacelab-Mir mission. Several experiments are in preparation.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The program has been reduced by a total of $22.7 million. In accordance with Congressional direction, a $25.0 million reduction has been accommodated by deferring development of hardware and experiments for the Space Station. These adjustments are offset by a $2.3 million increase due to the redistribution of ROS funding.

BASIS OF FY 1994 ESTIMATE

FY 1994 funds are required to continue basic and applied research activities as well as payload development for use in the Space Transportation System (STS) middeck, Spacelab, and Shuttle cargo bay for future flights of the USML and USMP series, as well as IML-2. Investigations are planned in electronic materials, metals and alloys, glasses and ceramics, biotechnology, combustion, fluid physics and dynamics. The future flight rates of these Spacelab missions remain largely dependent upon the Agency's plans for a future Space Station, currently under review.

FY 1994 begins the development of new equipment for the Shuttle middeck and other planned Spacelab missions. This new equipment will be used to carry out scientific investigations chosen from NASA Research Announcements in Combustion Science, Material Science, Biotechnology, Fluid Physics, and Fundamental Science. These investigations represent the future of the microgravity science program, as the results of USML-1, IML-1, and USMP-1 are disseminated and the program readies investigations for later Shuttle missions. Activities will continue in FY 1994 on the cooperative U.S./Russia Spacelab-Mir mission, scheduled for a 1995 launch. Funding will support the modification of several hardware items planned for flight aboard Mir, including the Advanced Protein Crystal Growth facility and the Space Acceleration Measurement System.

No funds are being requested at this time for Space Station hardware and related research. Requirements definition, design and development of hardware and experiments for the Space Station are being reevaluated consistent with the Agency's reexamination of its plans for development of the Space Station. A request for an appropriate level of funding in relation to the outcome of the redesign process will be submitted upon completion of that process.

BASIS OF FY 1994 FUNDING REQUIREMENT

SHUTTLE/SPACELAB PAYLOAD MISSION MANAGEMENT AND INTEGRATION

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Shuttle/Spacelab payload mission management and integration.....	(78,000)	(101,100)	(94,018)	117,700

OBJECTIVES AND STATUS

The primary objective of the Spacelab Payload Mission Management program is to manage the mission planning, integration, and execution of all NASA Spacelab and attached Shuttle payloads. This includes system management and engineering development of flight support equipment and software; development of certain interface hardware; payload specialist training and support; integration of the science payloads with the Spacelab system; payload flight operations; and data dissemination to experimenters.

Mission management activities are ongoing for several upcoming missions, such as the Atmospheric Laboratory for Applications and Science (ATLAS). The second of this series is planned for flight in FY 1993, with the third scheduled for 1994. The mission will incorporate a large number of instruments designed to support NASA's Mission to Planet Earth program of research. Other missions include flights of an imaging radar (SRL) beginning in FY 1994; a series of Spacelab Life Sciences (SLS) missions; the second flight of a cooperative International Microgravity Laboratory (IML-2); a series of U.S. Microgravity Payloads (USMP's), U.S. Microgravity Laboratories (USML's), and Microgravity Science Laboratories (MSL's); and a reflight of the Astro Spacelab mission (Astro-2) in 1994. Mission management activities also support other NASA payloads, for example, the Lidar In-space Technology Experiment (LITE), a 1994 launch, which will demonstrate technology and measurement techniques with high potential for use in studies of the Earth's atmosphere. Several Shuttle middeck experiments are also supported.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The net reduction of $7.1 million in FY 1993 reflects several actions. The following reductions were made: a $5.0 million reduction directed by Congress; a reallocation of $9.0 million to NASA's Academic programs to partially offset the impact of Congressional mandates; and a reallocation of $2.0 million to Life Sciences

to support the joint NASA/Mir mission These reductions were made possible due to extensive Shuttle manifest changes and the termination of the Canadian Waves in Space Plasma (WISP) mission. The reductiona are partially offset by the transfer of $3.0 million from Physics and Astronomy/Payload and Instrument Development to provide Spacelab support for the Astro-2 mission; an increase of $0.9 million due to the redistribution of ROS funding; and an increase of $5.1 million in order to support the flight of the Atlas-3 Spacelab mission in 1994.

BASIS OF FY 1994 ESTIMATE

Mission management activities will continue in FY 1994 with several Spacelab missions planned this fiscal year. Integration, testing, analysis and evaluation will continue for these major Shuttle/Spacelab missions including the IML-2, the first flight of the SRL-1, and the Atlas-3. Preparation for FY 1995 and subsequent missions will continue, including a significant effort devoted towards the cooperative Spacelab mission and rendezvous with the Russian MIR space station, scheduled for mid-1995.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1994 ESTIMATES

BUDGET SUMMARY

OFFICE OF MISSION TO PLANET EARTH

SUMMARY OF RESOURCES REQUIREMENTS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate	Page Number
		(Thousands of Dollars)			
Earth observing system	176.400	308.400	263.784	322.700	RD 6-7
Earth observing system data information system	77.670	82.600	130.651	182.700	RD 6-11
Earth probes	77.800	88.900	99.413	97.300	RD 6-13
Advanced communications technology satellite	18.700	3.600	3.968	3.000	RD 6-15
Ocean topography experiment	65.000	--	--	--	
Payload and instrument development	37.900	49.400	35.461	22.900	RD 6-16
Mission operations and data analysis	100.646	142.100	147.553	160.800	RD 6-19
Interdisciplinary research	2.340	2.600	4.453	5.000	RD 6-23
Modeling and data analysis	45.798	45.000	42.571	45.000	RD 6-24
Process studies	121.539	126.600	119.255	131.500	RD 6-27
Airborne science and applications	20.300	22.900	20.707	25.200	RD 6-30
Mission to planet earth information systems	--	--	--	11.800	RD 6-32
Research operations support	83.909	98.000	70.061	67.000	RD 6-34
Subtotal, mission to planet earth	828.002	970.100	937.877	1.074.900	
Information systems	35.000	40.700	36.193	(26.500)	RD 3-32 RD 6-32
Material processing in space. research and analysis	16.600	17.500	17.870	(18.400)	RD 5-14
Material processing in space. flight experimenta	104.200	177.800	155.064	(71.000)	RD 5-15
Search and rescue	1.300	1.000	1.018	(1.100)	RD 8-16
Subtotal. transferred programs	157.100	237.000	210.145	(117.000)	
Total	985.102	1.207.100	1.148.022	1.074.900	

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1994 ESTIMATES

BUDGET SUMMARY

OFFICE OF MISSION TO PLANET EARTH

SUMMARY OF RESOURCES REQUIREMENTS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Distribution of Program Amount by Installation				
Johnson Space Center	2,800	3,843	7,700	--
Kennedy Space Center	185	--	219	254
Marshall Space Flight Center	49,196	82,685	68,164	15,672
Stennis Space Center	369	853	436	508
Goddard Space Flight Center	461,835	507,251	529,711	581,384
Jet Propulsion Laboratory	158,550	290,066	183,289	182,805
Amea Research Center	35,909	59,997	42,987	38,932
Lewia Research Center	63,619	69,736	67,793	1,864
Langley Research Center	30,418	43,062	37,904	37,707
Headquarters	182,221	149,607	209,819	215,774
Total	985,102	1,207,100	1,148,022	1,074,900

OFFICE OF MISSION TO PLANET EARTH

OBJECTIVES AND JUSTIFICATION

The ongoing Mission to Planet Earth program is making critical near-term contributions to understanding the Earth as an integrated system as well as to environmental issues, including global warming and ozone depletion. NASA's base program combines ground-based measurements, laboratory studies, data analysis and model development with a progressive series of satellite missions, supporting cloud climatology, Earth radiation budget, ozone monitoring, atmospheric chemistry, and ocean circulation. The NASA program also supports a broad interdisciplinary, basic research program.

The ability to measure the extent of both the natural and man-induced changes in our global ecosystem is only a preliminary step - the capability to model and to predict the consequences of global change is the ultimate objective. The U.S. Global Change Research Program (USGCRP), in which NASA has been a major participant, provides a focused and effective mechanism for coordinating and directing federally-funded Global Change research.

The specific objectives of the NASA Mission to Planet Earth program are to improve our understanding of the processes in the atmosphere, oceans, land surface and interior of the Earth, and to advance our knowledge of the interactions between these environments. The program provides space observations of parameters involved in these processes and extends the national capability to predict environmental phenomena, both short- and long-term, and their interactions with human activities. Because many of these phenomena are global or regional, they can be most effectively, and sometimes only, observed from space. NASA's programs include scientific research efforts as well as the development of new technology for global and synoptic measurements. NASA's research satellite, Shuttle/Spacelab payload, and airborne science and applications programs provide a unique view of the planet Earth, its physical dynamics, and radiant energy and chemical processes that affect habitability and the solar-terrestrial environment.

NASA has established several significant objectives in the Mission to Planet Earth program for the next decade. Missions and research will emphasize advancement of our understanding of the upper atmosphere through the determination of the spatial and temporal distribution of ozone and select nitrogen, hydrogen, and chlorine species in the upper atmosphere and the sources in the lower atmosphere. NASA will characterize the current state of the terrestrial landscape, including the biosphere and the hydrosphere.

Investigators will use space-derived measurements to increase understanding of large-scale weather patterns. Researchers will increase capabilities for severe storm forecasting as well as knowledge of ocean productivity, circulation, and air-sea interactions. A long-term strategy for climate observation and prediction will improve knowledge of seasonal climate variability. Understanding the cycling of key biogeochemical elements, interactions between the biosphere and the climate system, the composition and evolution of the crust and the processes that shape the crust are essential to our understanding of the global environment.

The primary objective of the Earth Observing System (EOS) is to document global climate change and to observe regional-to-global scale processes. Utilizing several satellites, EOS will document global climate change over a fifteen-year period to provide long-term, consistent data sets for use in modeling and understanding global processes. This process and modeling research effort will provide the basis for establishing predictive global change models for policy makers' and scientists' use in formulating strategies to manage human impacts on global processes such as the greenhouse effect, ozone depletion, and deforestation.

The Earth Probes program provides small, specialized satellites and instruments for non-NASA satellites to complement data gathered by EOS. These satellites require special orbits and spacecraft capabilities and will provide data on tropical rainfall (Tropical Rainfall Measurement Mission (TRMM)), ocean wind speed and direction (NASA Scatterometer), and global ozone concentrations (Total Ozone Mapping Spectrometer (TOMS)). These missions are necessary for a complete understanding of the global climate systems.

The Advanced Communications Technology Satellite (ACTS) mission will be launched in 1993. The program will maintain United States leadership in the communications satellite market through the development and flight verification of advanced technologies that enhance the capability of communications satellites.

Launch of the Ocean Topography Experiment (TOPEX/Poseidon) occurred in August 1992. The launch and antenna deployments were successful and the satellite is operating normally. The objective of TOPEX/Poseidon is to acquire precise observations of the surface topography of the ocean. These data, in conjunction with the Scatterometer data, will enable the first determination of the wind forcing and ocean current response of the global oceans.

The objectives of the Payload and Instrument Development program are to develop, test, and evaluate Earth-viewing, remote sensing instruments and systems. Experimenters will obtain data necessary for basic research projects as well as provide correlative and developmental feasibility information for major free-flying spacecraft. Current instrument developments include the Atmosphere Trace Molecules Observed by Spectroscopy (ATMOS); Active Cavity Radar (ACR); Light Intersection Direction and Ranging (LIDAR); Measurement of Air Pollution from Satellites (MAPS); and the Shuttle Imaging Radar-C (SIR-C).

The Mission Operations and Data Analysis program actively collects data from operating Mission to Planet Earth missions. The Upper Atmospheric Research Satellite (UARS) and TOPEX/Poseidon missions are the most recent launches. NASA will obtain ocean color data for research use from the Sea-viewing Wide Field Sensor (SeaWiFS) instrument, planned for launch on SeaStar in 1994. The long-term ocean color data sets will contain data related to the biological productivity and ecology of oceans, seas, and larger lakes. The Nimbus spacecraft continues to collect unique data for the study of long-term trends of the Earth's atmosphere, oceans, and polar ice. The Earth Radiation Budget Experiment (ERBE), launched in 1984, continues to provide valuable data on total solar irradiance and its temporal variations.

The Interdisciplinary Research program will continue integrating discipline-specific research activities into a unified program that will help increase our understanding of critical global processes. Specific pilot studies are conducted, such as those concerning processes controlling atmospheric methane concentrations, changes in land surface properties and their effect on climate, and the role of oceans in the global carbon cycle.

The Modeling and Data Analysis program focuses on developing predictive models for global change and analyzing data sets to determine mechanisms at work in the global environment. The program emphasizes two major areas - physical climate and hydrological systems, and biogeochemistry and geophysics. Specifically, research will stress the development of coupled global atmosphere-ocean models to diagnose the present climate, to assess impact to the climate of increases in atmospheric trace gases such as carbon dioxide, and in experimental forecasting of climate on the inter-annual to decadal time scale. Researchers will work to improve techniques for assimilation of satellite data for model initialization and validation.

The Process Studies program will utilize a variety of techniques to develop an understanding of the processes at work in the global environment and to determine interdependencies that may impact global change management strategies. The program will utilize existing data sets and will conduct field experiments that will enable researchers to understand global environmental dynamics. Process studies concentrate on four major interdisciplinary categories - radiation dynamics and hydrology; ecosystem dynamics and biogeochemical cycles; atmospheric chemistry; and solid Earth science, including operation of the laser research facilities.

The Airborne Science and Applications program continues to provide aircraft-based platforms for observing and investigating mechanisms in ozone-depleting reactions in the atmosphere over the Arctic and Antarctic. The Airborne program also provides a variety of platforms for diverse studies in oceanography, terrestrial ecology, hydrology, soil studies, tropospheric chemistry, and geology. In addition, the FY 1993 program will focus on a number of international campaigns in Australia (Tropical Oceans Global Atmosphere Program (TOGA)) using the ER-2 and DC-8 aircraft, and Australia and South America for SIR-C precursor studies using the DC-8/AIRSAR (Airborne SAR) system. NASA canceled a planned FY 1993 volcanology study to Kamchatka, Russia, due to Congressional budget reductions that resulted in grounding of the C-130 aircraft in FY 1993.

The Mission to Planet Earth information system activity will continue supercomputing at the Goddard Space Flight Center (GSFC) and the Jet Propulsion Laboratory (JPL), including enhancements to keep pace with requirements.

The Research Operations Support (ROS) provides vital support to the civil service workforce and to the physical plant at the GSFC and at NASA Headquarters. Funding to support activities which directly benefit the NASA programs are included in the program budgets.

In FY 1994, NASA reorganized the Space Applications budget to include only Mission to Planet Earth activities. The Material Processing in Space Flight experiments and Research and Analysis budgets have been transferred to the Life and Microgravity Sciences and Applications program. The Information Systems program has been divided between the Space Science program and the Mission to Planet Earth program. The Search and Rescue activity has been transferred to the Commercial Use of Space program.

BASIS OF FY 1994 FUNDING REQUIREMENT

EARTH OBSERVING SYSTEM

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Instruments	114,000	--	--	--
Observatories	31,000	--	--	--
Science*	31,400	18,000	44,996	47,100
AM series	--	241,500	181,388	200,100
PM series	--	30,900	24,100	58,200
Chemistry	--	6,800	1,100	1,500
Special spacecraft	--	11,200	12,200	15,800
Total	176,400	308,400	263,784	322,700
Launch vehicles	--	(2,900)	(2,800)	(20,100)

* The FY 1993 Budget Estimate included interdisciplinary science only. The FY 1993 Current Estimate includes all EOS science.

OBJECTIVES AND STATUS

The objective of the Earth Observing System (EOS) is to acquire a long-term set of comprehensive measurements of various aspects of the Earth system. The EOS program will provide the basis for predictive global climate change models for policy makers' and scientists' use in formulating strategies to mitigate human impacts on global processes such as the greenhouse effect, ozone depletion, and deforestation. The EOS program fulfills the science requirements of the Intergovernmental Panel on Climate Change (IPCC).

The EOS program will provide comprehensive measurements of parameters affecting global climate change. The program includes three U.S. flight series: the AM, PM, and Chemistry. The special spacecraft include the Altimetry and Aerosol series, which will depend on international participation, and the possible flights of some instruments on Japanese, European, and other international spacecraft. EOS also includes an ocean color data purchase. The science budget supports interpretation of the collected data. The AM, PM, and Chemistry flight series will be designed to last five years, flying three times, making measurements over fifteen-year periods. The AM series science objectives are to measure physical and radiative properties of

clouds; air-land exchanges of energy, carbon, and water; and vertical profiles of carbon monoxide and methane. The PM series will study cloud formation, precipitation, and radiative properties; air-sea fluxes of energy and moisture; and sea-ice extent and heat exchange with the atmosphere. The remaining EOS missions will examine aerosol and chemical properties of the troposphere and stratosphere, ocean altimetry and circulation, and ice sheet mass balance.

The EOS missions will monitor many parameters that are indicators of the state of the environment, such as the spatial and temporal distribution of tropospheric and lower stratospheric gases. In addition, interdisciplinary theoretical investigations will utilize EOS data sets and complementary data sets to study such phenomena as ecosystem distributions and conditions; biogeochemical fluxes at the ocean-atmosphere and land-atmosphere interfaces; the global carbon cycle; and atmospheric composition.

During 1992, the EOS program was significantly replanned in response to the constrained agency budgetary environment. While reducing the overall cost of the mission, NASA maintained the ability to meet the science objectives of the IPCC. The result is a program essentially similar to the restructured program submitted in the FY 1993 budget, with the incorporation of a number of cost-saving process improvements: implementing a common spacecraft approach for the follow-on U.S. series; adopting a build-to-cost approach for the first unit of a multiple instrument build; and increasing reliance on the cooperation of international and other U.S. partners. NASA deleted from the program the High Resolution Imaging Spectrometer (HIRIS) instrument, the highest technical development risk instrument, assuming that a continuing Landsat program will meet many of the HIRIS science objectives.

Taking maximum advantage of work already in process, the AM-1 spacecraft will be unique, to support the unique instrument combination planned for the first EOS flight. The follow-on flight series are being designed to use a common spacecraft. The AM series, with a morning equatorial crossing, the PM series, with an afternoon equatorial crossing, and the Chemistry series will fly as intermediate-size spacecraft. The other missions are small-class spacecraft, taking full advantage of international cooperation.

Concurrent with the replanning exercise, work has continued in unaffected areas: the AM-1 spacecraft began the subsystem Preliminary Design Review (PDR) cycle, and the AM-1 instruments continued to progress through the preliminary design stage. The Clouds and Earth's Radiant Energy System (CERES) instrument completed a successful PDR, and the Canadian Space Agency selected the development contractor for Measurement of Pollution in the Troposphere (MOPITT), the last AM-1 instrument to enter the full-scale development phase. NASA has issued directions to implement the replanning/rescoping exercise changes. Definition-phase contracts were awarded for the common spacecraft buy for the follow-on flights.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The changes in the FY 1993 budget estimates are a result of a realignment within the total EOS program. The increase in the Science budget is due to the reallocation of mission science tasks associated with the individual flight series to the Science program. In addition, funding for science computing facilities and science data product capability development previously included in the individual EOS missions have been transferred to the EOS Data and Information System (EOSDIS) budget. These adjustments include a $2.3 million increase due to the redistribution of Research Operations Support (ROS) funding.

BASIS OF FY 1994 ESTIMATE

During FY 1994, all aspects of the AM-1 flight development will be fully under way. NASA will complete Critical Design Reviews (CDR's) for the AM-1 instruments - Clouds and the Earth's Radiant Energy System (CERES), Moderate-Resolution Imaging Spectrometer (MODIS), Multi-Angle Imaging Spectro-Radiometer (MISR), Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER), and Measurements of Pollution in the Troposphere (MOPITT). Japan and Canada are developing the ASTER and MOPITT instruments, respectively. In support of these CDR's, the instrument developers will build engineering models for test and evaluation by the end of FY 1994. The three U.S.-made instruments will begin fabrication of the protoflight units in 1994. The spacecraft subsystem (e.g. structures, thermal control, command and data handling, etc.) CDR's for the AM-1 spacecraft will also be conducted in FY 1994, in preparation for the spacecraft system level CDR in FY 1995 leading to flight in 1998. The last of the spacecraft subsystem components (e.g., star trackers, solar array, etc.) will have been awarded to subcontractors by early 1994. With the successful completion of these CDR's, drawings will have been released and manufacturing organizations will fabricate the space flight hardware.

Preliminary design activities will continue on the instruments planned for the PM-1 flight. Of particular importance is the need to maintain progress on the development of the Atmospheric Infrared Sounder (AIRS), an effort which is technologically demanding and has been under way since the initial selection of AIRS for EOS-A1 in FY 1991. Of the other instruments planned for PM-1, two are copies of instruments already being built for AM-1; these instruments will have a compressed design schedule with both PDR and CDR occurring during 1994. The remaining instruments, which include two supplied by the international community, will be in the preliminary design phase, which includes the initiation of engineering model builds and long-lead parts buys. Results of the definition studies for the follow-on EOS spacecraft (AM-2,-3; PM-1,-2,-3; CHEM-1,-2,-3) will be incorporated into a request for proposal, which is planned for release to industry in early FY 1994. Proposals for the spacecraft development contract will be evaluated and a selection made in 1994. This will lead to initiation of full-scale-development of the PM-1 flight in 1995, for a launch in calendar year 2000.

The procurement process associated with the ocean color data purchase will be initiated in 1994 to ensure data coverage after 1998.

In FY 1994, the EOS science principal investigatora and science facility teama continue development of the EOS science and analysis algorithms. They also continue to support the EOSDIS development by defining science requirementa of the EOSDIS Core System algorithm development tool kits due at the end of calendar year 1994. Phased deliveries of the tool kits throughout 1994 will lead to the preliminary science software for AM-1 in 1995. The science software deliveries are critical itema toward achieving the final data producta from the acience instruments.

BASIS OF FY 1994 FUNDING REQUIREMENT

EARTH OBSERVING SYSTEM DATA INFORMATION SYSTEM

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Earth observing system data information system.....	77,670	82,600	130,651	182,700

OBJECTIVES AND STATUS

A key element enabling EOS to meet the program's long-term science goals, and those of Mission to Planet Earth, is the Data and Information System (EOSDIS). The EOSDIS will provide the processing, storage, and distribution of the EOS science data and the resulting scientific products. The EOSDIS system will also have the capability for spacecraft and instrument command and control. Additionally, EOSDIS will provide data archive and distribution and information management for all NASA Mission to Planet Earth data.

The EOSDIS will be evolutionary, with capability phased to support the requirements of the rescoped EOS program and those of other Mission to Planet Earth spacecraft and data sources. The Distributed Active Archive Centers (DAAC's) will perform continuous processing of instrument data to derive the underlying scientific parameters of interest. The network will link the archived data and products so that investigators may access the entire set of holdings from any entry point. An information management service will help users locate data within the total archive. The network also will interface with international partner instruments and control facilities and will provide operational data to agencies such as the National Oceanic and Atmospheric Administration (NOAA).

The EOSDIS includes the development of operational ground systems for spacecraft and instrument command and control, the EOS Data Operations System (EDOS) and the EOS Communications System (ECOM). These systems accept data from the Tracking and Data Relay Satellite System (TDRSS) ground terminal, process it, and deliver data products to the scientists through the EOSDIS. The EOSDIS also provides for the Independent Verification & Validation (IV & V) of the EOSDIS core system.

In 1992, the EOS program was significantly replanned in response to the constrained agency budget environment. The replanning affected EOSDIS by limiting the data products available at time of launch to those of only the highest scientific priority and by planning for early transition of the DAAC focus from

Version 0 development to engineering of the Version 1 operational DAAC's. NASA deferred transfer of data sets from pre-existing systems where they are independently accessible. Information Management System (IMS) prototyping and Version 0 interoperability involving all DAAC's will be maintained.

NASA selected the core system contractor for EOSDIS (Hughes Applied Information Systems, Inc.) in late 1992, with contract award planned for early 1993. NASA is progressing on the preliminary work with Pathfinder data sets to establish the Version 0 EOSDIS, providing researchers with early access to data sets from EOS precursor missions and from Earth probes flown before EOS. The major Version 0 event planned for 1993 is the first formal demonstration of the Version 0 prototype, to include the browse product integration, the integration with the Earth sciences Master Directory, and the graphical user interface and the data dictionary. The procurement process for the EDOS and IV & V segments is under way. NASA completed the ECOM requirements review, deciding to implement the ECOM segment in-house.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The changes in the FY 1993 budget estimates are a result of the realignment within the total EOS program. Funding for the science computing facilities and science data product capability development were reallocated to EOSDIS from the individual EOS missions. These adjustments include a $1.2 million increase due to the redistribution of Research Operations Support (ROS) funding.

BASIS OF FY 1994 ESTIMATE

FY 1994 funding is required to accomplish the first major EOSDIS milestone: completion of the Version 0 prototype information system for operational use by the Earth science research community. Version 0 will provide Earth science researchers with a comprehensive, interdisciplinary "Earth science view" of existing and near-term, pre-EOS NASA Mission to Planet Earth data. The Version 0 program will include development of interoperable linkages between DAAC's for IMS functions, including evolution toward a common user interface. Two prototype demonstrations for evaluation and test are scheduled for 1993, thus in early 1994, time will be devoted to incorporating recommended changes, streamlining the intended operations, and correcting software "bugs." Version 0 developers will complete the system architecture, with final integration and testing scheduled to be complete in 1994.

The EOSDIS Core System (ECS) development will also be fully under way in 1994, incorporating Version 0 capabilities, lessons learned, tested standards, etc. ECS is planned as an evolutionary development, with the initial release in 1995, supporting pre-EOS mission datasets. To support the 1995 ECS 1 release, both preliminary and critical design reviews are scheduled in 1994, in addition to a design review dedicated to the results of the Version 0 prototype. The independent verification and validation activities will also commence in 1994, in time to support the ECS design reviews. The EOS Data Operations System (EDOS) contract will be awarded to begin development for a 1998 operational readiness. In-house EOS Communications (ECOM) activities will be progressing toward the system CDR. A request for proposal for commercial communications software for ECOM will be released in early 1994, with award scheduled for late in the year.

BASIS OF FY 1994 FUNDING REQUIREMENT

EARTH PROBES

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Scatterometer.....	28,000	20,200	20,200	18,700
Total ozone mapping spectrometer.....	30,800	18,700	27,685	9,800
Tropical rainfall measurement mission..	19,000	50,000	51,528	68,800
Total.....	77,800	88,900	99,413	97,300
Launch vehicles (TOMS).....	(6,300)	(1,200)	(4,200)	(1,800)

OBJECTIVES AND STATUS

The Earth Probes program is a component of Mission to Planet Earth that addresses specific, highly-focused problems in Earth science research. The program has the flexibility to take advantage of unique opportunities presented by international cooperative efforts or technical innovation. The Earth probe missions complement the Earth Observing System program by providing the ability to investigate processes that require special orbits or have unique requirements. The currently approved Earth probes are the Total Ozone Mapping Spectrometer (TOMS), NASA Scatterometer (NSCAT), and Tropical Rainfall Measurement Mission (TRMM). The first TOMS mission was delayed eight months due to cost growth in the instrument and spacecraft contracts.

The TOMS is a set of instruments and one spacecraft for launch on a small-class expendable launch vehicle in 1994, and on the Japanese Advanced Earth Observing System (ADEOS) Satellite in 1996. The first TOMS mission was delayed eight months due to cost growth in the instrument and spacecraft contracts. The ADEOS launch date was delayed one year by the Japanese due to problems in the development of the H-II launch vehicle. The TOMS instrument flights will provide uninterrupted data on total atmospheric ozone concentrations. The TOMS flights build on the experience that began in 1978 with the launch of a TOMS instrument on Nimbus-7 and continues with the TOMS instrument on the Russian Meteor-3, launched in 1991.

The NSCAT will provide accurate, global measurements of ocean surface winds, useful for both oceanography and meteorology. In addition, NSCAT data will permit the first global study of the influence of winds on ocean circulation, providing data on the effects of the oceans on the atmosphere and improved marine forecasting on winds and waves. The NSCAT will also fly on the Japanese ADEOS satellite in 1996.

The TRMM spacecraft will measure precipitation in the tropical latitudes from a dedicated Earth probe. The Japanese and the United States will sign a Memorandum of Understanding in 1994. The United States will provide the spacecraft, integration, and four instruments. The Japanese will provide the 1997 launch and a rain radar.

CHANGES FROM FY 1993 BUDGET ESTIMATE

In FY 1993, $9.2 million was reallocated from the Payload and Instrument Development budget to the Earth Probes program. $8.7 million will fund cost growth in the TOMS instrument and spacecraft contracts, with $0.5 million to support development of the TRMM Microwave Imager instrument. These adjustments are increased by $1.3 million due to the redistribution of Research Operations Support (ROS) funding, $0.3 million for TOMS and $1.0 million for TRMM.

BASIS OF FY 1994 ESTIMATE

The FY 1994 funding is required to continue development of the NSCAT instrument, leading to a 1996 launch. In FY 1994, the NSCAT instrument will be integrated on the Japanese ADEOS tower, the spacecraft fixture on which NSCAT will operate, and shipped to Japan for spacecraft integration and testing. Additionally, the NSCAT science data processing will continue development. FY 1994 funding is also required for the system integration of the TOMS 1994 flight, including the satellite system environmental test, preparation of the satellite for launch, and associated on-site activities. In parallel, the ADEOS TOMS instrument will be fabricated, tested, and shipped to Japan for spacecraft integration and test. Development of TRMM will proceed in FY 1994 with design and development activities scheduled for the spacecraft, instruments, ground system, and the science data and information system. The TRMM spacecraft critical design review is scheduled for FY 1994.

BASIS OF FY 1994 FUNDING REQUIREMENT

ADVANCED COMMUNICATIONS TECHNOLOGY SATELLITE

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Advanced communications technology satellite (ACTS).....	18,700	3,600	3,968	3,000
Upper stage.....	(16,700)	(7,400)	(17,500)	(--)

OBJECTIVES AND STATUS

The Advanced Communications Technology Satellite (ACTS) program will maintain United States leadership in the communications satellite market through the development and flight verification of advanced technologies that enhance the capability of communications satellites.

The United States user community, representing private sector organizations and other government agencies, will develop and execute experiments that will test and evaluate the ACTS technologies under various applications scenarios. The key ACTS technologies include high effective isotropic radiated power; fast-hopping multiple beam antenna; on-board intermediate frequency and baseband switching; Ka-band components; and dynamic rain fade compensation techniques. The ACTS team has completed the final flight system testing in 1992 and in early 1993 delivered it to the Kennedy Space Center launch site for final integration with the Transfer Orbit Stage (TOS) and launch aboard the Space Transportation System (STS) in the summer of 1993. Final test of the ground system will be completed prior to launch.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The $0.4 million increase is due to the redistribution of Research Operations Support (ROS) funding.

BASIS OF FY 1994 ESTIMATE

The FY 1994 budget provides for the continuation of the mission operations for the ACTS flight and ground systems. Mission operations will continue for two years. The ACTS experiments program is funded and conducted under the Commercial Use of Space program.

BASIS OF FY 1994 FUNDING REQUIREMENT

PAYLOAD AND INSTRUMENT DEVELOPMENT

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Atmospheric payloads.....	12,887	15,500	12,330	11,712
Earth sensing payloads.....	25,013	33,900	23,131	11,188
Total.....	37,900	49,400	35,461	22,900

OBJECTIVES AND STATUS

The objective of Atmospheric Payloads is to provide information related to the chemical constituency and dynamics of the Earth's atmosphere. The objective of the Earth Sensing Payloads is to demonstrate the technology and algorithms needed to make multi-frequency, multi-polarization active radar measurements of the Earth's surface (i.e., land, sea, and ice). Together, the two programs will provide measurements crucial to enhancing the understanding of the role of the Earth's atmosphere and surface during global change.

The Space Shuttle offers a unique opportunity for short-duration flights of instruments. The Mission to Planet Earth program has incorporated this capability into the Shuttle/Spacelab payload development in these important aspects: early test, checkout and design of remote sensing instruments for long-duration, free-flying missions and short-term atmospheric and environmental data gathering for basic research and analysis where long-term observations are impractical. Instrument development activities support a wide range of instrumentation, from airborne to international flights of opportunity.

The objective of the Atmosphere Trace Molecules Observed by Spectroscopy (ATMOS) experiment is to make detailed measurements of gaseous constituents (e.g., hydrogen chloride, water, ammonia, methane) in the Earth's atmosphere by using the technique of infrared absorption spectroscopy. The data will help determine the compositional structure of the upper atmosphere, including the ozone layer and its spatial variability on a global scale. The instrument first flew in 1985 on Spacelab-3 and again on ATLAS-1 in 1992. The science results from these flights of ATMOS were of exceptional value, and the basic capability of ATMOS to measure very low concentrations of trace species in the Earth's atmosphere was clearly demonstrated. The instrument is to fly again on ATLAS-2 and ATLAS-3 in 1993 and 1994.

The Measurement of Air Pollution from Satellites (MAPS) experiment is a gas-filter correlation radiometer designed to measure the levels of troposphere carbon monoxide and the extent of inter-hemispheric mass transport in the lower atmosphere. The instrument was flown successfully on two Shuttle flights. It is planned for two more STS flights in 1994 to provide the first observations of the global seasonal variation of carbon monoxide in the Earth's atmosphere.

The Light Intersection Direction and Ranging (LIDAR) Technology Experiment (LITE) is an advanced technology Earth atmosphere sensing experiment incorporating the next generation of solid-state lasers. The laser application will provide measurements of higher resolution and accuracy than current spaceborne instruments of stratospheric and tropospheric aerosols, planetary boundary layer heights, and cloud top temperature and density.

Like LITE, the LIDAR Atmospheric Sensing Experiment (LASE) is also an advanced technology Earth atmospheric sensing experiment which will incorporate the next generation of solid-state lasers. Starting in FY 1994, NASA plans to fly the instrument routinely on the ER-2 aircraft to obtain water vapor measurements at improved resolution and accuracy than current instruments. These measurements will support studies in global hydrology, meteorology, radiation budget, climate and atmospheric transport, and chemistry.

The Solar Ultraviolet Spectral Irradiance Monitor (SUSIM) is designed to make very accurate measurements of the sun's ultraviolet radiation, which is the primary sources of energy for the Earth's atmosphere. SUSIM has flown on three previous STS flights and is planned for reflights on ATLAS-2 and ATLAS-3.

The Shuttle Solar Backscatter Ultraviolet (SSBUV) instrument provides correlative measurements with SBUV/2 instruments that fly on NASA and NOAA spacecraft. Both instruments measure the amount and height distribution of ozone in the upper atmosphere. These measurements help resolve any data reliability problems resulting from calibration drift. SSBUV is planning to continue flights through the rest of the decade.

The Active Cavity Radiometer-1 (ACR-1) is designed to aid in the study of the Earth's climate and the physical behavior of the sun by making solar constant measurements. Reflights of ACR-1 on ATLAS-2 and -3 are planned for 1993 and 1994.

The Shuttle Imaging Radar-C (SIR-C) will explore regions of Earth's surface that are not well characterized because of vegetation, cloud, or sediment cover. These radar studies will lead to a better understanding of ocean and land surface, and subsurface processes on a global scale. Currently, SIR-C is in the environmental test and assembly phase with two launches aboard the Space Shuttle scheduled for 1994.

Advanced spectrometer technology development activities include fundamental research in remote sensing involving airborne and spaceborne imaging spectrometer instruments. The imaging spectrometer and linear array solid-state sensor research focuses on the development of such features as inherent geometric and spectral registration and programmable high spatial and spectral resolution.

CHANGES FROM FY 1993 BUDGET ESTIMATE

$9.2 million has been reallocated from the payloads program in order to provide $8.7 million to TOMS for instrument and spacecraft cost growth, and $0.5 million to TRMM to support development of the TRMM Microwave Imager instrument. These reductions have been accommodated through significant reductions in reserves and the deferral of advanced technology development activities. $5.1 million has been transferred to the Physics and Astronomy Shuttle/Spacelab Payload Mission Management and Integration budget to provide for the mission management and integration of ATLAS-3 and Shuttle Radar Laboratory (SRL) missions. These adjustments are partially offset by a $.3 million increase due to the redistribution of Research Operations Support (ROS) funding.

BASIS OF FY 1994 ESTIMATE

FY 1994 funds will be used to support the MAPS environmental testing with new ground support equipment. Funding for ATMOS, SUSIM and ACR-1 is required to support continuing flights in 1993 and 1994. This includes science team activities, data processing and analysis, and limited refurbishment. In FY 1994, the LIDAR program will have the flight model of the LASE instrument delivered, integrated and routinely flown on the ER-2 aircraft. The SIR-C and LITE experiments will be delivered to the Kennedy Space Center for integration, test and checkout prior to their 1994 launch.

BASIS OF FY 1994 FUNDING REQUIREMENT

MISSION OPERATIONS AND DATA ANALYSIS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Upper atmosphere research satellite operations	30,515	35,400	36,663	31,000
Ocean topography experiment operations	4,846	29,000	31,614	31,200
Ocean color mission data purchase	13,000	14,900	15,570	9,600
Consortium for international Earth science information networks	25,000	--	12,300	--
Landsat	7,500	25,000	25,000	59,100
Earth science mission operations and data analysis	19,785	37,800	26,406	29,900
Total	100,646	142,100	147,553	160,800

OBJECTIVES AND STATUS

The objective of the Earth Science Mission Operations and Data Analysis program is to acquire, process, and archive long-term data sets produced by space missions. These data relate to issues of global change research in atmospheric ozone and trace chemical species, the Earth's radiation budget, aerosols, sea ice, land surface properties, and ocean circulation and biology. Funding provides for operations of spacecraft, processing of acquired data, validation of the resulting data products by science teams, and development of new processing software by these science teams.

The Upper Atmosphere Research Satellite (UARS) was launched in September 1991. The mission will provide data related to the chemistry and dynamics of the atmosphere above the tropopause for a period of at least three years. Various instruments aboard UARS are measuring temperature, composition, and winds in the Earth's atmosphere, as a function of altitude, over ninety-eight percent of the Earth's surface, from eighty degrees South latitude to eighty degrees North. These data will provide important information related to maintenance and destruction of the ozone layer. Correlative measurements are a key element of the UARS science objectives. Ground-based, balloon, and sounding rocket measurements of the

atmosphere are used to validate and calibrate UARS instrument measurements, refining the accuracy of the derived geophysical parameters. All UARS instruments are operational except for the United Kingdom's Improved Stratospheric and Mesospheric Sounder (ISAMS) instrument, which failed in July 1992.

NASA's Ocean Topography Experiment (TOPEX) and the French Poseidon mission were launched as a single ocean spacecraft miasion, TOPEX/Poseidon, in August 1992. This mission will provide data on the surface topography and currents of the Earth's oceans for a period of at least three years. These data will provide critical information related to the circulation of the Earth's oceans and the Earth's climate.

In the ocean color mission data purchase, NASA will purchase ocean color data for research use from the SeaWiFS instrument launched on the SeaStar spacecraft in 1994. This imaging data, which will be obtained in several visible and infrared wavelengths, will be processed and archived, resulting in long-term data sets related to the biological productivity and ecology of the world's oceans, seas, and larger lakes.

On Nimbus-7, the Stratospheric Aerosol Measurement II (SAM-II) instrument continues to add to a twelve-year data set on atmospheric aerosols and stratospheric clouds in the Earth's polar regions. Data from the Total Ozone Mapping Spectrometer (TOMS) instrument on Nimbus-7 continue to provide accurate maps of total atmospheric ozone, as they have since launch in 1978. This instrument was joined in space by a TOMS instrument on the Russian Meteor-3 spacecraft launched in 1991.

Data from the Solar Backscatter Ultraviolet/2 (SBUV/2) instruments, on the NOAA-9 and NOAA-11 satellites, provide column abundances and vertical profiles of atmospheric ozone beneath the orbital tracks of these satellites, continuing the collection of a data set begun with the SBUV instrument on Nimbus-7 in 1978. A carefully calibrated version of the same instrument, called Shuttle SBUV (SSBUV), has been flown four times on the Space Shuttle and will continue to fly periodically in the 1990's. The SSBUV provides correlative measurements so that the TOMS and SBUV instruments flying on other spacecraft can be more accurately calibrated, and provides information on the diurnal variability of stratospheric ozone in low latitudes.

On the Earth Radiation Budget Satellite (ERBS), data from the Stratospheric Aerosol and Gas Experiment II (SAGE-II), launched in 1984, continue to provide vertical profiles of aerosols, ozone, and other trace gas species over the Earth's tropical and mid-latitude regions.

The Earth Radiation Budget Experiment (ERBE) is comprised of three identical instrument packages flying on NOAA-9, NOAA-10, and NASA's ERBS. These instruments continue to provide data on the temporal and spatial variations in the Earth's radiation budget, which drive the Earth's climate. Data from the Earth Radiation Budget (ERB) instrument on Nimbus-7, and from the ERBE instruments, provide the only continuous data set on total solar irradiance (solar constant) and its temporal variations stretching from 1978 to the present.

NASA's Alaska Synthetic Aperture Radar Facility (ASF), based at the Geophysical Institute at the University of Alaska in Fairbanks, began acquisition and processing of Synthetic Aperture Radar (SAR) data transmitted from the European Space Agency's Earth Remote Sensing Satellite-1 (ERS-1) in early 1991 and the Japanese Earth Remote Sensing Satellite-1 (JERS-1) in mid-1992. Data from the Canadian RadarSat spacecraft will also be acquired and processed after its launch in 1995. These data will provide important information on the properties and dynamics of sea ice and other land and ocean processes in the polar regions.

The Consortium for International Earth Science Information Network (CIESIN) serves as an affiliated data center for NASA's EOSDIS program. It will facilitate the access to and use of Mission to Planet Earth data for Earth science research and public policy making. The CIESIN is currently analyzing existing and prospective Earth science research information resources and current national and international plans for data integration, analysis and modeling.

The Federal Government is committed to the continued acquisition of Landsat-type data for national security, global change research, and other Federal, state, local, and private sector users needs. The Department of Defense (DOD) is responsible for the procurement and launch of the Landsat-7 spacecraft, with NASA responsible for flight operations and data processing, distribution and archival. The contract for procuring Landsat-7 was awarded by DOD in October 1992.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The increase of $5.5 million reflects a Congressionally-directed general reduction of $15.0 million, offset by the addition of funding for the CIESIN program, and a $0.5 million increase due to the redistribution of Research Operations Support (ROS) funding.

BASIS OF FY 1994 ESTIMATE

Operations of the Nimbus-7 and ERBS spacecraft and processing and analysis of their data will continue, as will processing and analysis of data from NOAA-based and Shuttle-based SBUV instruments. Processing and analysis of SAR data acquired at the ASF from European Space Agency's ERS-1 will also continue and be augmented by similar processing and analysis of SAR data from Japan's JERS-1. Operations of the TOPEX spacecraft and processing and analysis of its data will continue. Operation of the UARS spacecraft will continue to the end of FY 1994. Processing and analysis of data from the TOMS instrument flying on the Russian Meteor-3 spacecraft will continue. Processing and analysis of data from various NASA SAR instruments (including an airborne version) will continue, in preparation for flight on SIR-C in 1994. Funding will be continued to allow for the eventual purchase, processing, and analysis of ocean color data.

Development of the ground segment (ground processing and mission operations systems) of the Landsat program as well as a Tracking and Data Relay Satellite System (TDRSS) communication antenna for the Landsat-7 satellite will continue. The ground processing system will include satellite command, control, telemetry, data processing, product generation, and data archival. An early priority will be to preserve the existing Landsat 1-5 archive by transferring the data to a more stable medium. FY 1994 funding requirements for the CIESIN program are under review and will be submitted to the Congress on the same schedule as that of the Space Station redesign.

BASIS OF FY 1994 FUNDING REQUIREMENT

INTERDISCIPLINARY RESEARCH AND ANALYSIS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Interdisciplinary research and analysis.....	2,340	2,600	4,453	5,000

OBJECTIVES AND STATUS

Interdisciplinary research activities are conducted to characterize quantitatively the Earth's chemical, physical, and biological processes on the land, along with the interactions between the land, the oceans, and the atmosphere, which are of particular importance in assessing the impact of these phenomena on global, physical, and biogeochemical processes. Such research is essential to investigating and assessing long-term physical, chemical, and biological trends and changes in the Earth's environment. Included in the program activities are joint efforts from a variety of disciplines, such as atmospheric science, climatology, biological sciences, geochemistry, and oceanography.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The $1.9 million increase is due to the redistribution of Research Operations Support (ROS) funding.

BASIS OF FY 1994 ESTIMATE

In FY 1994, interdisciplinary studies will be continued with emphasis on integrating discipline-specific research activities of oceanic processes, atmospheric dynamics and radiation, upper atmosphere/troposphere chemistry, and land processes into a unified program which will help increase our understanding of critical global processes. Emphasis will be placed on specific pilot studies such as those understanding the biogeochemical processes controlling the concentration of atmospheric methane, characterizing changes in properties of the land surface and their effect on climate, and understanding the role of the oceans in the global carbon cycle.

BASIS OF FY 1994 FUNDING REQUIREMENT

MODELING AND DATA ANALYSIS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Physical climate and hydrologic systems modeling and data analysis.....	29,463	28,000	26,862	27,100
Biogeochemistry and geophysics modeling and data analysis.....	16,335	17,000	15,709	17,900
Total.....	45,798	45,000	42,571	45,000

OBJECTIVES AND STATUS

The research and analysis activities within the Physical Climate and Hydrologic System program provide a focus for contributing to an improved understanding of the fully-integrated geophysical climate system, its interactions and predictability, through the development and multi-disciplinary exploitation of global satellite observations of the Earth, numerical modeling, climate impact assessments, and sensitivity studies. The two principal components of the program are in the areas of climate modeling research and climate data analysis.

The objectives of the Physical Climate and Hydrologic Systems Modeling Research program are to develop and improve global circulation models which assimilate and optimize the use of satellite-derived data sets for understanding climate interactions; to help guide the design of the global observing system, and to improve the capability for reliable climate diagnosis and forecasting. The program builds on the broad foundation established over the past decade of research on geophysical modeling conducted under the NASA atmospheric dynamics and radiation and ocean processes programs.

The objectives of the Physical Climate and Hydrologic Data Analysis program are to assemble a long-term global record of climate parameters, with an emphasis on satellite remote sensing, for specifying and analyzing the state of the climate system and its variability. These include the full range of geophysical variables which describe the structure and composition of the atmosphere, oceans, land surfaces, and cryosphere, as well as their boundaries, interfaces, and external forcings. The program builds on earlier accomplishments achieved through such diverse research initiatives as the International Satellite Cloud Climatology Project (ISCCP), the Earth Radiation and Budget Experiment (ERBE), the Global Atmospheric

Research Program (GARP) and current activities in support of the Tropical Oceans Global Atmosphere Program (TOGA) and the World Ocean Circulation Experiment (WOCE). These programs are elements of the World Climate Research Program (WCRP), sponsored by the World Meteorological Organization and the International Council of Scientific Unions. Such international relationships are strongly encouraged by the U.S. Global Change Research Program plan.

The Biogeochemistry and Geophysics Modeling and Data Analysis has as its objectives the development of global change models dealing with all aspects of the biology, chemistry, geology, and geophysics of the Earth system, with the exploitation of satellite data in the monitoring of global change as well as the study of the mechanisms which are at work in the global environment. There are four major elements to the program: ocean biogeochemistry, atmospheric chemistry, geophysical modeling and analysis, and ecology and land atmosphere interactions.

In the ocean biogeochemistry program element, the emphasis is on data analysis efforts utilizing existing satellite data sets to understand better the variations in ocean productivity and preparing improved algorithms and data systems for the Ocean Color Mission.

The atmospheric chemistry program element is centered on the numerical modeling and analysis of measurements trace constituents in the troposphere-stratosphere system. Numerical models are used to test our understanding of atmospheric chemistry and of the way in which meteorological processes affect the trace constituent distribution in the atmosphere. Models are also used to predict future changes to the chemical composition of the atmosphere.

Research in geophysical modeling and analysis consists of modeling and analysis of the Earth's internal structure and dynamics through measurements of the gravitational and magnetic fields, Earth rotation and polar motion, and geodetic properties. The spatial variability of the potential fields and the temporal variability of the motion fields are the critical observational parameters.

In the ecology and land atmosphere interactions program element, global scale observations are analyzed to understand the current state of terrestrial ecosystems, to assess their natural variability, and to determine the impacts of anthropogenic forcings. Numerical models and multi-temporal satellite observations are used to study sources and sinks of biogeochemical species and to investigate the interactions of climatic events such as El Nino with surface biology and atmospheric composition. Theoretical modeling of ecosystem functioning and land atmosphere interactions is conducted using global circulation models with explicit, interactive biospheres.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The Modeling and Data Analysis was reduced by $3.6 million to fully fund the FY 1993 request for Landsat. This reduction is offset by a $1.5 million increase due to the redistribution of Research Operations Support (ROS) funding and a $0.3 million internal adjustment.

BASIS OF FY 1994 ESTIMATE

The ocean biochemistry program element will increase the emphasis on modeling of the chemical interactions between the oceans, land and atmosphere. In atmospheric chemistry, emphasis on multi-dimensional modeling of the troposphere will be increased. The studies in ecology and land atmosphere interactions will place increased emphasis on ecosystem sources of key trace species in the atmosphere.

The analysis of ERBE data will lead to reliable predictions of climate change at the regional level using general circulation models. The SeaWiFS science team will begin their analysis of ocean color data from the new satellite. Initial focus will be on defining higher level data products needed for global change studies. The newly formed Nimbus-7/METEOR-3 TOMS science team begin similar activities to define data products, especially those needed for impact assessments. In all program elements, new work will emphasize analysis of existing data sets generated within the NASA pathfinder program.

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BASIS OF FY 1994 FUNDING REQUIREMENT

PROCESS STUDIES

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Radiation dynamics and hydrology.....	33,166	34,000	31,560	34,700
Ecosystem dynamics and biogeochemical cycles.....	23,300	23,100	23,679	26,800
Atmospheric chemistry.....	29,873	30,300	28,111	32,000
Solid Earth science.....	25,900	30,200	27,680	28,700
Laser research facilities.....	9,300	9,000	8,225	9,300
Total.....	121,539	126,600	119,255	131,500

OBJECTIVES AND STATUS

The research and analysis activities within the Radiation Dynamics and Hydrologic Processes program combine a core effort of theoretical, laboratory, and field investigations essential to understanding the basic geophysical processes and their interactions which control climate. The two principal components of the program are in the areas of radiation and dynamic processes research and hydrologic processes research.

The objectives of the radiation and dynamics research program are to improve our understanding of the basic physical processes by which the atmospheric system transforms, stores and transports energy. Understanding atmospheric dynamics is essential to understanding how the atmosphere behaves and its role in determining climate and climate change.

The objectives of the hydrologic processes research program are to improve our understanding of the physical processes which govern the hydrological cycle and its impact on the atmosphere and oceans. The prediction of global change in the geosphere and biosphere will be one of the most important problems in environmental sciences in the twenty-first century. Estimation of the distribution and transport of carbon, nitrogen, sulfur, etc., cannot be obtained without knowledge of the atmospheric circulation and water cycle on regional and global scales.

The Ecosystem Dynamics and Biogeochemical Cycles program conducts research on the function of global ecosystems and the interactions of the Earth's biota with the atmosphere and hydrosphere. Particular emphasis is placed on understanding land atmosphere interactions and the carbon cycle. The two principal components of the program are the ecosystem dynamics program element and the biogeochemical processes program element.

The goal of the ecosystem dynamics program element is to achieve an improved understanding of the role of the biosphere and the biologically-linked components of the hydrologic cycle in processes of global significance. Specific objectives are to develop understanding of the ecological controls on the exchanges of energy, water, and nutrients between ecosystems and the atmosphere, the response of ecosystems to change, and the biophysics of remote sensing of ecosystem properties.

The goal of the biogeochemical processes program element is to achieve an improved understanding of the sources, sinks, fluxes, trends, and interactions involving the biogeochemical constituents within the Earth system, with an emphasis on their major biospheric reservoirs, including oceanic and terrestrial systems. A major focus is on developing a better understanding of terrestrial and oceanic primary productivity and the fluxes of carbon within these ecosystems and between them and their biotic environment.

The Atmospheric Chemical Processes program is composed of two elements: the upper atmospheric research program (UARP) and the tropospheric chemistry program (TCP). The UARP is a large, comprehensive research program with NASA playing a leadership role as mandated by Congress under the Clean Air Act of 1976 and the FY 1976 NASA Authorization Act. The program aims at expanding our knowledge of the physical, chemical, and meteorological processes that control the concentration and distribution of atmospheric ozone, thereby providing the necessary input for large-scale global models used to predict the future state of stratospheric composition. The TCP is focused on tropospheric chemical change, the natural and anthropogenic processes that cause it, and its effects on global climate and on the chemistry of the stratosphere through troposphere-stratosphere exchange.

One of the primary challenges in the study of the Earth as a system is understanding the extent and causes of atmospheric chemical changes and their consequences, including stratospheric ozone depletion and potential global climate change.

The Solid Earth Science program conducts research in the fields of geology and geodynamics with the goal of improving our understanding of the evolution, structure, and dynamics of the Earth's interior and surface by testing hypotheses through a vigorous program of measurement and analysis of space-based geodetic, remote sensing, space-based geopotential, and related data. In geodynamics, emphasis is placed on understanding the rates and mechanisms of the Earth's crustal deformation from local to global scale and how these reflect historical global change or influence current processes of global change. In geology, emphasis is placed on the interaction of the solid Earth with the hydrosphere, atmosphere and biosphere in programs under development and implementation in the early 1990's which address soil development and erosion, volcano-climate interaction, and coastal processes.

The objective of the Laser Research program is to measure the movement and deformation of the tectonic plates of the Earth. Laser ranging to satellites and the moon, microwave interferometry using astronomical radio sources and transmissions from the Global Positioning Satellite system (GPS) are used to determine precise position locations.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The Process Studies program was reduced by $11.4 million to fully fund FY 1993 requirements for Landsat. Biochemical processes was increased $1.6 million through the transfer of the Biospheric program from Life Sciences. These adjustments are increased by $2.5 million due to the redistribution of Research Operations Support (ROS) funding.

BASIS OF FY 1994 ESTIMATE

FY 1994 funding is required in the area of radiation and dynamics research to continue studies of the processes associated with cloud-radiation feedback, ocean circulation and heat flux. Research and analysis studies will continue, focusing on forest ecosystem dynamics, marine primary productivity, regional trace gas fluxes, and the biophysics of remote sensing. Analysis of the First International Satellite Land Surface Climatology Project (ISLSCP) Field Experiment (FIFE) data set, Hydrologic Atmosphere Pilot Experiment (HAPEX)-Sahel experiment data, and various multi-sensor airborne campaign data sets will continue. Both of the atmospheric chemical process programs will continue their activities to investigate and understand the global atmosphere through laboratory studies and field measurement campaigns. The solid Earth program will pursue its geodynamics research activities in large part through the Fiducial Laboratories for International Natural Science Network. The geodynamics program will continue definition studies to develop, in partnership with the European Space Agency (ESA), a Gravity and Magnetic Experiment Satellite (GAMES), using gravity radiometry and magnetometers to study at high resolution the variability of Earth's gravity and magnetic fields.

BASIS OF FY 1994 FUNDING REQUIREMENT

AIRBORNE SCIENCE AND APPLICATIONS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Airborne science and applications.....	20,300	22,900	20,707	25,200

OBJECTIVES AND STATUS

The Airborne Science and Applications effort requires operation of ER-2, C-130, and DC-8 aircraft in order to support Earth remote-sensing and atmospheric research. They may serve as test beds for newly-developed instrumentation and allow demonstration of new sensor techniques before their flight on satellites or on Shuttle/Spacelab missions. Data obtained from these aircraft are used to refine analytical algorithms, and to develop ground data handling techniques. For example, the ER-2 acquires stratospheric air samples and conducts in-situ measurements at altitude ranges above the capability of more conventional aircraft and below those of orbiting satellites. This capability is important in gaining an understanding of stratospheric transport mechanisms. The DC-8 carries a wide variety of instruments, ranging from a large complement of atmospheric sensors, to LIDAR's and a three-frequency synthetic aperture radar used in surface process studies. The program is also responsible for all maintenance, system upgrades and spares for the aircraft.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The Airborne program was reduced by $3.1 million consistent with Congressional direction. This has resulted in a deferral of all environmental research conducted aboard the C-130 aircraft until FY 1994. Required ground maintenance of the aircraft will continue in the interim. These adjustments are offset by a $0.9 million increase due to the redistribution of Research Operations Support (ROS) funding.

BASIS OF FY 1994 ESTIMATE

The Airborne Research Program provides a variety of platforms in support of studies of the biosphere, troposphere and stratosphere. Platforms include a modified C-130, a long-range DC-8 that has been uniquely modified to accommodate a wide variety of specialized instrumentation for atmospheric and Earth surface remote sensing studies, and high-altitude ER-2's, which are a unique national resource. Several major campaigns are in the planning stages, including a nearly year-long investigation of the Antarctic ozone.

The ozone flights are tentatively planned for Christchurch, New Zealand. The international BOREAS campaign, which will involve all the platforms, is planned for nearly nine months, with basing in the United States and Canada. Another Global Tropospheric Experiment over the north Pacific using the DC-8 will be conducted over a six-week period in early 1994. In addition, the DC-8/AIRSAR (Airborne SAR) system will underfly the SIR-C (Shuttle) mission in 1994. An ER-2 will also be used for a large number of LIDAR Atmospheric Sensing Experiment (LASE) instrument (airborne LIDAR) tests.

The majority of these science flights are related to EOS investigations - contributing to algorithm development for EOS precursor instruments, and supporting individual university principal investigator research studies. The NASA airborne platforms also support other Federal agencies in support of their specific global research.

BASIS OF FY 1994 FUNDING REQUIREMENT

MISSION TO PLANET EARTH INFORMATION SYSTEMS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Mission to planet earth information systems.....	(35,000)	(40,700)	(36,193)	11,800

OBJECTIVES AND STATUS

Through FY 1993, the Information Systems program is made up of four major discipline areas: scientific computing, science data management and archiving, science networking, and information systems research and analysis. In addition, the important function of conveying facts about NASA's information and data management systems is part of program management responsibility. Beginning in FY 1994, the ongoing Information Systems program has been reallocated among the Space Science and the Mission to Planet Earth programs.

The information systems program within the Mission to Planet Earth program provides scientific computing support to further the Mission to Planet Earth research goals. The specific emphasis is access to supercomputing capability for the large-scale numerical models which simulate physical, chemical, and dynamic processes in the Earth environment. This is done primarily through the NASA Center for Computational Science (NCCS) at the Goddard Space Flight Center (GSFC) and the supercomputing facility at the Jet Propulsion Laboratory (JPL). Both facilities continue to upgrade capacity to keep pace with growing requirements. A major replacement to a new technology supercomputer at the NCCS is planned for the last quarter of 1993.

The information systems role in the High Performance Computing and Communications (HPCC) program will lead to advances in computing and related technologies to further Mission to Planet Earth objectives related to global change.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The change from the FY 1993 Budget Estimate is due to a Congressional reduction of $5 million and has been accommodated by deferring some planned activities. This adjustment was offset in part by a $0.5 million increase due to the redistribution of Research Operations Support (ROS) funding.

BASIS OF FY 1994 ESTIMATE

Beginning in FY 1994, support for NASA's Information Systems program will be divided between the Mission to Planet Earth and the Space Science programs. Space Science will support three of the four areas of science data management and archiving, science networking, and information systems research and analysis. Mission to Planet Earth Information Systems will continue scientific computing.

The funding will continue the NCCS at GSFC and the JPL supercomputer, including enhancements to keep pace with requirements. The NCCS will upgrade to the latest technology supercomputer system in the first quarter of FY 1994.

BASIS OF FY 1994 FUNDING REQUIREMENT

RESEARCH OPERATIONS SUPPORT

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Research operations support.....	83,909	98,000	70,061	67,000

OBJECTIVES AND STATUS

Research Operations Support (ROS) funding provides vital support to the civil service workforce and to the phyaical plant at the Centers and at NASA Headquarters. This funding supports the basic core administrative functions such as personnel, payroll, accounting, procurement and legal counsel. It also supports centerwide services for civil service staff, such as mail, telephones, janitorial services, transportation, medical (other than astronaut), security, and fire protection, as well as maintenance of roads, grounds, and all requirements of administrative buildings. Funding to support activities which directly benefit the NASA programs are included in the program budgets.

CHANGES FROM FY 1993 BUDGET ESTIMATE

In FY 1992, establishment of the ROS was initially accomplished by transferring funds contained in the Operation of Installation account in the Research and Program Management appropriation to the Research and Development and Space Flight, Control and Data Communications appropriations. During FY 1993, a more detailed examination of activities supported by ROS funding was conducted by the program offices to identify activities directly related to program activities. Funding for activities dedicated to a single program was transferred to the benefiting program. In total, the decrease in ROS funding reflects the transfer of $22.1 million consistent with the restructuring activity offset by a reduction of $5.8 million consistent with Congressional direction to reduce ROS funding.

BASIS OF FY 1994 ESTIMATE

The FY 1994 estimate is the result of intensive cost cutting activities which respond to NASA's internal commitment to hold down costs in all areas and also to the recent executive order mandating reductions in adminiatrative expenses. As such, it reflects the minimum funding to support administrative and facility maintenance requirements at the NASA Centers and NASA Headquarters. This includes administrative services that support all civil service employees, facility maintenance, maintenance of roads, grounds and requirements of administrative buildings.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1994 ESTIMATES

BUDGET SUMMARY

OFFICE OF ADVANCED CONCEPTS AND TECHNOLOGY

SPACE RESEARCH AND TECHNOLOGY

SUMMARY OF RESOURCES REQUIREMENTS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate	Page Number
		(Thousands of Dollars)			
Research and technology base.....	140,850	173,800	158,113	160,800	RD 7-6
In-Space technology expariments program	15,074	--	--	--	
Civil space technology initiative (CSTI) program.....	82,948	158,200	114,616	137,400	RD 7-18
Space automation and telerobotics.....	37,900	--	--	--	
Exploration technology program.....	28,900	--	--	--	
Exploration mission studies.....	3,500	--	--	--	
Total.....	309,172	332,000	272,729	298,200	
Distribution of Program Amount By Installation					
Stennis Space Center.....	640	500	270	300	
Johnson Space Center.....	15,090	14,100	6,550	7,700	
Kennedy Space Center.....	2,673	4,600	2,380	3,800	
Marshall Space Flight Center.....	25,202	27,500	20,000	23,300	
Goddard Space Flight Center.....	21,845	18,500	16,803	23,800	
Jet Propulsion Laboratory.....	44,186	48,800	49,450	56,700	
Ames Research Center.....	31,643	35,400	23,906	28,600	
Langley Research Center.....	55,066	61,800	47,525	50,600	
Lewia Research Center.....	72,939	75,700	64,703	66,300	
Headquarters.....	39,888	45,100	41,142	37,100	
Total.....	309,172	332,000	272,729	298,200	

OFFICE OF ADVANCED CONCEPTS AND TECHNOLOGY

SPACE RESEARCH AND TECHNOLOGY

OBJECTIVES AND JUSTIFICATION

In 1993, the Office of Commercial Programs (OCP) and the Space Research and Technology program of the Office of Aeronautics and Space Technology (OAST) were merged to create a new organization, the Office of Advanced Concepts and Technology (OACT). The OACT will be the NASA focal point for technology innovation and transfer. The focus of the new office will be to support the development and application of technologies critical to the economic, scientific, and technological competitiveness of the U.S. and to promote U.S. industrial preeminence through strengthened linkages between the private sector and NASA technology efforts.

Specifically, the mission of OACT is to pioneer innovative, customer-focused space concepts and technologies, leveraged through industrial, academic, and government alliances to ensure U.S. competitiveness and preeminence in space. Several goals for the new organization have been established:

- to be a center of systems engineering excellence performing concept definition and evaluation studies for NASA, industry, and commercial applications;

- to be a nationally recognized customer-oriented focal point for solicitation, evaluation, and implementation of innovative technology and products for space and terrestrial applications;

- to establish new alliances and mechanisms to develop and transfer technology to create new self-sustaining industries, improve performance, reduce costs, and demonstrate benefits and potential of dual-use technology; and,

- to develop and promote the unique attributes of space for new commercial products and services.

In FY 1994, OACT will complete the refocus of its programs and begin a more aggressive pursuit of the transfer of technology from NASA to the private sector, enhanced partnerships between the private sector and NASA, and development of critical technologies essential to future NASA and commercial missions. Following is a description of the OACT activities, the Space Research and Technology program and the Commercial programs.

The overall goal of the Space Research and Technology program is to provide advanced, enabling technologies, validated at a level suitable for user-readiness, for future space missions. To achieve this goal, the Space Research and Technology program will continue to support a broad-based activity to advance the state-of-the-art at the concept, subsystem and system level; to develop technical strengths in the engineering disciplines within NASA, industry, and academia; and to perform critical flight experiments in areas where testing in the space environment is necessary for technology development.

In FY 1994, the Space Research and Technology program will consist of two complementary parts: the Research and Technology (R&T) Base and a focused program, the Civil Space Technology Initiative (CSTI). The R&T Base program will continue to serve as the seedbed for new technologies and capability enhancement. Fundamental research will be conducted in critical disciplines, and high-leverage technology advances and concepts will be brought to the level of demonstrating proof of principle. The In-Space Technology Experiments program, now as part of the R&T Base, will continue to support the development of small flight experiments to conduct research and to validate critical technologies that cannot be accomplished on the ground.

The CSTI is composed of five strategic thrusts -- space science technology, transportation technology, planetary surface technology, space platforms technology, and operations technology which are intended to be highly responsive to the user community's needs. The CSTI, as a focused program, will continue to provide specifically for the development of selected technologies at larger scale or higher level of maturity and, as required, in the relevant environment of space, for more effective transfer to the user programs. These advanced technology efforts will significantly enhance current capabilities to access, operate in, and explore space. The technology developed by these efforts will reduce mission costs and increase safety and reliability.

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CHANGES FROM FY 1993 BUDGET ESTIMATE

The Space Research and Technology program has been reduced by a net amount of $59.3 million. This reduction is the result of a Congressional general reduction of $65.0 million (which was allocated by reducing the R&T Base by $18.5 million and CSTI by $46.5 million), a reallocation of $5.1 million of hypersonic funding to the Aeronautical Research and Technology Base, a reallocation of $0.1 million to Research Operations Support (ROS) in the Aeronautics Research and Technology budget offset by the transfer of $10.9 million due to the redistribution of the ROS funding program.

BASIS OF FY 1994 ESTIMATE

The FY 1994 Space Research and Technology program is a critical step towards responding to the strong and continuing consensus that investments in advanced research and technology (R&T) are essential to our future success in space. A healthy and aggressive Space Research and Technology program is a vital element in

contributing to our National competitiveness. The FY 1994 Space Research and Technology program will continue to assure the effective development of the advanced technologies necessary for our Nation's future space missions. The narratives that follow discuss in greater detail highlights of FY 1993 accomplishments and planned FY 1994 activities.

In FY 1994, the Research and Technology Base program will continue to serve as the seedbed for new technologies and capability enhancement. Several changes initiated in FY 1993 in the research and technology base will continue, such as increased emphasis on high-leverage technologies, including control of space structures, automation and robotics and micro spacecraft technology development. Other changes in FY 1993 include the consolidation of five of the R&T Base programs which were formally implemented at up to six field centers. The number of field centers have been reduced to two or three to increase management and funding efficiency.

The CSTI program focuses on research in five categories: space science, planetary surface, transportation, space platforms and operations. The CSTI is a vital component of NASA's Space Research and Technology program, intended to build NASA's technical strength and to provide options for high-priority future civil space goals. Over the last few years, the ongoing CSTI program has been severely constrained. Throughout the program there are key activities that need to be revitalized to keep America at the forefront of research and technology. The CSTI's research efforts are critical to ensure that the capabilities to accomplish future space missions will be available when needed. The following discusses the CSTI program thrusts.

The space science technology thrust is developing the advanced technology for observations from future space and Earth science missions. Specific program areas are in science sensing and observatory systems. The principal program emphasis will be on creating technology options and improvements for the next decade's space science missions, such as the Earth Observing System (EOS), as well as providing the enabling technologies for missions beyond the end of the decade. In FY 1994, continuing efforts will be expanded in direct detectors, submillimeter sensing, laser sensing, coolers and cryogenics, and micro-precision controls/structures integration.

The planetary surface technology thrust will focus on technologies for the robotic exploration of the solar system to support future science missions. In particular, the program will develop technology for small rovers that could be used for the scientific exploration of Mars.

The transportation technology thrust is primarily concerned with providing the technology needed for future major transportation improvements. The overall goal of the transportation technology thrust is to develop and validate technologies that will provide new capabilities for current and future space transportation vehicle systems, reduce life-cycle costs, substantially improve safety margins and reliability, and increase system availability. In FY 1994, additional emphasis also will be placed on facilitating the transfer of these emerging technologies to the commercial space sector through joint or cooperative activities with industry.

The space platforms technology thrust is primarily concerned with providing the technology needed for future space platforms for the following mission classes: unmanned Earth orbiting platforms in low-Earth orbit or geosynchronous Earth orbit, manned Earth orbiting platforms (space stations), and deep-space platforms. The overall technology goal is to enhance future science, exploration, and commercial missions by providing lightweight, durable, stable, and accurately pointed platforms, and highly efficient platform utilitiea. Once achieved, these advances will lead to reductions in spacecraft launch weight, (reduced life-cycle costa by decreasing on-orbit maintenance and logistics resupply needs) and increased lifetime operability. In FY 1993, new emphasis was placed on micro-spacecraft technology for the early design studies of Earth Probe missions and outer planet missions. This focus will continue in FY 1994.

The goal of the operations technology thrust is to develop, validate, and transfer technologies to reduce the cost of NASA operations, improve the safety and reliability of those operations and enable new, more complex, activities to be undertaken. It will also provide the high capacity data transfer, storage and processing that is implicit in expanding scientific and exploration endeavors. Significant results have already been achieved, and the program will build on these successes in the future. The thrust will provide technology for NASA users and the commercial sector and will support major operational improvements for future robotic and human missions both on the Earth and in space.

BASIS OF FY 1994 FUNDING REQUIREMENT

RESEARCH AND TECHNOLOGY BASE

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Aerothermodynamics research and technology	14,400	14,400	10,400	10,200
Space energy conversion research and technology	11,403	12,600	10,800	10,800
Propulsion research and technology	15,258	14,700	12,900	13,100
Materials and structures research and technology	21,797	23,500	21,000	21,100
Space flight research and technology	16,530	16,000	12,700	13,200
In-space technology experiments program	(15,074)	16,700	19,200	19,700
Systems analysis	6,523	6,400	6,613	8,400
University space research	17,130	18,600	18,600	18,600
Information and controls technology	10,369	21,300	17,500	17,500
Human support technology	7,186	8,100	9,200	8,900
Space communications	20,254	21,500	19,200	19,300
Total	140,850	173,800	158,113	160,800

OBJECTIVES AND STATUS

The objective of the Research and Technology Base program is to gain greater knowledge and understanding of the fundamental aspects of phenomena in critical engineering disciplines and to provide needed technology products for both near- and far-term missions. The Research and Technology Base program consists of nine program elements: aerothermodynamics, space energy conversion, propulsion, materials and structures, space flight, systems analysis, information and controls, human support, and space communications. In addition, the university space research program, supported by the research and technology base, includes research in critical areas to enhance and broaden the capabilities of the Nation's academic community to participate more effectively in the U.S. civil space program. A description of the objectives and status of the elements of the Research and Technology program follows.

The Aerothermodynamics program provides for fundamental understanding and prediction of the detailed aerodynamic and thermodynamic loads experienced by high-speed vehicles during ascent, entry and maneuver in both the Earth and other planetary atmospheres. This activity is enabling to the successful development and design of advanced aerospace vehicles and is pursuing the following objectives: (1) development and application of advanced computational methods and numerical techniques covering the entire spectrum of continuum, transitional, and rarefied flows; (2) development of accurate and detailed real-gas chemistry and high-speed turbulent flow models and the efficient integration of these models with standard computational flow codes; (3) establishment of a high-quality ground and flight experimental data base for code validation and verification; (4) direct correlation and comparison of computations with available ground and flight data; (5) establishment of a detailed aerothermal loads data base and development of fully integrated analysis techniques; and (6) enhancement of engineering design codes and advanced configuration analysis capability to support rapid evaluation of future vehicle/mission concepts. In FY 1993, significant accomplishments included the successful completion of the analysis of Space Shuttle leeside heating and demonstrated agreement with the Orbiter Experiments program (OEX) Shuttle Infrared Leeside Temperature Sensing (SILTS) flight measurements. The program also completed the HL-20 personnel launch system (PLS) concept definitions and configuration analysis. Progress continues to be made in development of advanced computational fluid dynamics (CFD) codes which incorporate thermochemical nonequilibrium effects and coupled radiation; development of a flight test capability sufficient to validate computational predictions and provide correlation for ground test data bases; and extending the level of sophistication and efficiency of engineering design codes for configuration assessment.

The objective of the Space Energy Conversion program is to provide the space power research and technology base for future Agency and national needs. Major thrusts are to improve performance, reliability and tolerance to the atomic oxygen, plasma and radiation environments while reducing power system cost and mass for systems operating in low-Earth orbit (LEO), geostationary orbit (GEO) and planetary environments. The research is aimed at providing the technology base for power systems ranging from 10's of watts to 10's of kilowatt (kW) to eventually megawatt electric (MWe) levels. Areas include photovoltaics, electrochemical energy storage, fault tolerant power management and distribution components and subsystems, spacecraft environmental interactions, integrated spacecraft bus technology, solar thermal and dynamic systems, advanced radiator concepts and surfaces, and thermal control of advanced power electronics. Significant technical accomplishments in FY 1992-FY 1993 include the development of a fiber optic current sensor technology; progress in photovoltaics systems with five times improvement in watts to kilogram (w/kg), Ni-H2 batteries with two times W-hr/kg and ten times improvement in LEO lifetime and successful demonstration of a thermal energy conversion system, alkalai metal thermal to electric conversion (AMTEC) technology system, with improvements of twice the lifetime (1900 hours) and a 13 percent increase in efficiency. Major progress has also been made in the space environmental compatibility area leading to castings and spacecraft designs that have been incorporated into satellites to ensure long-lived performance in this harsh environment.

The Propulsion program defines, develops and transfers technologies for future NASA, commercial, and Department of Defense (DOD) transportation missions. Applications include launch to orbit transfer, and ascent/descent vehicles, planetary spacecraft and Earth-orbiting satellites utilizing both chemical and electrical propulsion systems. Emphasis is placed on technologies which materially add to U.S. capabilities and competitiveness in space. Advanced propulsion concepts which can be developed into spacecraft propulsion systems capable of strongly enhancing the missions of interest to NASA in the first decades of the 21st century will be evaluated. Systems studies will be performed to assess the theoretical benefits of proposed advanced propulsion concepts in terms of quantifiable attributes such as required initial mass in Earth orbit or flight time. Significant technical accomplishments in FY 1992-FY 1993 include the selection of arcjet propulsion technology for orbit control on four new commercial satellite systems; the baselining of high temperature-oxidation resistant coated apogee engines on a new commercial satellite; and the baselining of plasma contactors on the Space Station which are directly derived from ion propulsion technologies.

The Materials and Structures program focuses on extended space durability and environmental effects, lightweight structures for space systems, and technology to enable the development of space structures and advanced space transportation systems with significant improvements in performance, efficiency, durability, and economy. Materials technology focuses on: fundamental understanding of the processing, properties and behavior of advanced space materials; development of lightweight space-durable materials; computational methods in chemistry to enable the prediction of physical properties and environmental interactions involving materials under space and reentry conditions; nondestructive measurement science for advanced materials; tribological aspects of materials behavior in the space environment; and the development of a wide variety of metallic, intermetallic, ceramic and carbon-carbon materials for thermal protection systems. Structures technology focuses on: the development of erectable and deployable structural concepts; methods for in-space construction, monitoring, and repair of large complex structures; dynamics of flexible structures and vibration suppression; new structural concepts for cryogenic tanks for advanced Earth-to-orbit rocket propulsion systems, future space transportation vehicles, and orbital transfer vehicles; and efficient analysis and design methodology for advanced space structures, including multidisciplinary analysis and optimization. During FY 1992, continued analysis of the data returned by the Long Duration Exposure Facility (LDEF) has contributed to the knowledge of the low-Earth environment, improved models for the prediction of meteoroid and debris fluxes, provided data on performance of a wide variety of coatings and prediction of long-term performance of selected exterior spacecraft materials, and is continuing to prove valuable in the development of a comprehensive, Agencywide space environment and effects program. Completion of the LDEF data analysis is scheduled for FY 1995. Protective coatings for atomic-oxygen sensitive polymers have been developed and demonstrated. Newly-developed structural ceramic ablator shows improved ablation performance compared to traditional materials. Space structures research developed erectable truss hardware which was demonstrated on orbit and assisted the INTELSAT retrieval; two high-performance, low-weight shields were developed which provide the same protection level with 50 percent weight savings; and, extravehicular activity (EVA) assembly procedures for a precision reflector were verified in neutral buoyancy.

Areas addressed by the Information and Controls program include computer science, sensors, photonics, controls, guidance, automation and robotics, and human factors. In the computer science area, the thrusts of the research program includes access to and management of very large scientific data sets and real time hardware and software for the Kennedy Space Center (KSC) Orbiter Processor Facility shop floor automated system; software engineering tools for generation of very complex and reliable software; and innovative and highly effective computation approaches emphasizing non-linear fuzzy logic controls. The primary objective of the photonics research is to develop advanced opto-electronic components and system concepts and to implement a high-speed optical sensor and sensing and electronic devices for high energy science observation missions. In the controls area, the goal is to reduce by orders of magnitude the size of guidance and controls components for micro-spacecraft. In automation and robotics, research will continue to concentrate on advanced sensors and mechanisms to support telerobotics vehicle health management and the development of advanced artificial intelligent concepts applicable to the problems of critical interest to the country. Progress continues to be made in the development of a set of techniques which collectively are called virtual interactive environment workstation or artificial reality. A data base for virtual exploration of the Mars surface and an Earth-analog environment has been established.

The Space Communications program focuses on the development of critical high risk devices, components, and analytical methods in support of NASA missions, U.S. commercial satellite communications industry, and other government agencies. The program contributes to the preservation of U.S. preeminence in satellite communications technology. The advanced research focuses on the areas of microwave and millimeter-wave devices, digital systems development, optical communications and mobile communications systems. The goal is to develop enabling technologies which are bandwidth and power efficient, have extended lifetimes, and are low in weight and volume. In the radio frequency technology area, continuing advancements in antennas, satellite switching, low noise receivers, high power amplifiers are being achieved. State-of-the-art performance was demonstrated in a high efficiency, Ka-band traveling wave tube amplifier capable of operating in the deep space environment; radio frequency power and efficiency have been increased by a factor of two. The digital systems technology focuses on the development of high speed modems and codes, information and switching processors, and autonomous network control; extensive use of in-house computer-aided design facilities are utilized for microprocessor, expert system and neural network applications. The primary objective of the optical communications research is to develop the integrated technologies required to develop optical transceiver systems for satellite laser crosslinks. The unique accomplishments during FY 1992 were the completion of mobile terminal design and design review, completed fabrication of a 220 MBS optical communications receiver, and the completed construction of a Ka-band small reflector antenna.

In the Human Support program, extravehicular operations by astronauts will be aided by a new technology in a high-pressure extravehicular glove design and new thermal control methods for life support. For environmental control and life support systems, the goal is to provide a technology base in chemical processing techniques to support future human space missions. Closed-loop life support chemical processing technologies will provide recycled air and water for crew consumption to eliminate or significantly reduce mission resupply requirements. In FY 1993, increased emphasis was placed upon developing a fully integrated

life support system from various component technologies for air, water, and waste processors, including chemical and microbial sensors and integrated system controls to assure safe operation and safe human consumption of recycled air and water. In this first year of life support sensor technology development, progress has been made in producing selected micro-sensor elements capable of detecting individual chemical and microbial species which may be present in recycled air and water systems. An integrated life support system testbed utilizing existing field center facilities was also initiated which will incorporate both sensor and process control technologies to achieve safe, reliable operation and characterization of closed life support systems.

The purpose of the In-Space Technology Experiments program and the Space Flight Research and Technology program is to support flight validation of innovative technologies developed in ground-based programs and to facilitate the transfer of technology from NASA, universities or industry to NASA or commercial flight programs. In June 1992, the Environmental Verification Experiment was launched on the Extreme Ultraviolet Explorer (EUVE) spacecraft. This experiment has been returning data for six months on the space environment around the spacecraft. Analysis of the data will enable the updating of existing environmental models to be used in the design of advanced, more efficient spacecraft. Other accomplishments include flight of the Orbital Acceleration Research Experiment (OARE) in June 1992 as part of the Orbiter Experiments program (OEX). The OEX started with the first Shuttle flight (STS-1) utilizing Columbia as a research vehicle to characterize aerodynamic and aerothermodynamic performance of the Shuttle. The data collected over the years by the 12 OEX experiments have been an important source for designing and developing performance improvements in the present orbiter program and have supplied data for validating models for the design of future space transportation vehicles. As part of OEX, OARE collected and returned orbital and re-entry acceleration data from the STS-50 flight in June 1992 of the Space Shuttle Columbia.

To facilitate the design of advanced thermal management systems for spacecraft, two heat pipe experiments were launched on the Shuttle in October and December 1992 respectively. These experiments have tested the performance characteristics of heat pipes of various designs and materials. The results have contributed considerably to the engineering data base needed for the design of highly efficient and reliable thermal systems in space. Experiments to complete this data base are planned for the future. Also in October 1992, the second flight of the Tank Pressure Control Experiment was accomplished onboard the Shuttle. This time the experiment focused on collecting data on thermal phenomena which are needed for the design of advanced cryogenic tanks. During FY 1993, the hardware development of seven experiments will be completed and readied for launch in FY 1994. In addition, approximately fifty new experiments will be selected for feasibility study from the 345 proposals received in response to the Announcement of Opportunity issued in November 1992. These new experiments are expected to be ready for launch starting in late 1995. They will be flown on the Shuttle, expendable launch vehicles, and the Space Station.

The objective and structure of the Systems Analysis program were revised in FY 1993 to focua on key space system issues as well as to identify critical technologies for future space missions for NASA, DOD, and commercial missions. The results of these studies will be used directly to formulate and/or redirect the Space Technology program to address and provide critically needed technologies for both government and industry needs. The program has been consolidated and assigned to three field centers, each focusing on a specific area of systems analysis and technology identification, in concert with U.S. space program goals and objectives. At Langley Research Center (LaRC), the systems analysis focus will be on new transportation systems that identifies technology requirements for competitive launch systems for the U.S. At Lewis Research Center (LeRC) systems analysts efforts are studying the benefits of nuclear propulsion systems for future space missions, including the required pacing technologies to enable future transportation systems. The Jet Propulsion Laboratory (JPL)'s role in the Systems Analysis program is to conduct the necessary studies and technology trades for future science spacecraft and/or platforms. FY 1993 accomplishments include the restructuring of this vital program, the concept definition and technology options for a single-stage-to-orbit advanced manned launch system, and a benchmark assessment of two-stage-to-orbit advanced manned launch system. The identification of system level issues and technology options offering optimum small/micro-spacecraft system performance will also be completed in FY 1993. These planned accomplishments will be utilized to direct and focus the entire Space Technology program as appropriate space systems and technologies are identified.

The objective of the University Space Research program is to enhance and broaden the capabilities of the Nations's engineering community to participate more effectively in the U.S. civil space program. This program is an integral part of the strategy to strengthen the Nation's space research and technology base. The program elements include the University Space Engineering Research Center program, which supports interdisciplinary research centers at selected universities and the University Advanced Space Design program, which funds senior level advanced systems study courses. In FY 1992, a third element of the university program, the University Innovative Research program, which provided grants to individuals with outstanding credentials, was completed. High priority, user-oriented research previously funded by this program will be supported by the appropriate Base R&T program. Also in FY 1992, a comprehensive peer review of all nine university space engineering research centers was conducted to obtain peer reviews of progress, measured against the original program objectives, and to obtain recommendations concerning the future of each center. As a result of this peer review process, the centers received very strong recommendations for continuation. One center was not continued beyond FY 1992. Significant technical accomplishments are emanating from these centers. For example, antiprotons, injected at peak compression of uranium-hydrogen, have been demonstrated to trigger microfission in subcritical experiments for inertial fusion propulsion; high performance Very Large Systems Integration Reed Soloman processor have been developed and delivered to NASA, the only certified decoder capable of operating at the Tracking and Data Relay Satellite (TDRS) rates; developed miniature micro-flow sensor and technique for bonding to almost any substrate; developed the first 250 GHz planor monolithic receiver. These centers are attracting, retaining, and training a unique multidisciplinary cadre of graduate students and attracting increased industry support.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The Space Research and Technology Base reflects a decrease of 15.7 million. This is the net reault of the distribution of the appropriations general reduction of $18.5 million, the reallocation of $5.1 million of hypersonic research funding to the aeronautics research and technology base, the reallocation of $0.1 million to Research Operations Support (ROS) in the Aeronautical Research and Technology budget offaet by the transfer of $8.0 million due to the redistribution of the ROS funding. The reduction directed by Congress impacts planned activities within the NASA field centers as well as universities and induatry.

The reductions/changes by discipline program are as follows:

Aerothermodynamics Research and Technology has been reduced by a total of $4.0 million. This consiats of the net effect of $1.2 million hypersonic funding reallocated to the aeronautics research and technology base, a $4.3 million reduction to accommodate the Congressionally-directed reduction which was accomplished by eliminating overlap and duplication in field center efforts and by eliminating specific research tasks associated with exploration missions, offset by the transfer of $1.5 million due to the redistribution of ROS funding.

The Space Energy Conversion Research and Technology program has been reduced by a total of $1.8 million which reflects a net effect of a reduction of $2.6 million as part of the Congressional reduction which was achieved by consolidation of thermal management research activities at one field center, a decrease in photovoltaic research and a phase out of the alkalai metal thermal to electric conversion (AMTEC) technology, offset by the transfer of $0.8 million due to the redistribution of ROS funding.

The Propulsion Research and Technology was reduced by a total of $1.8 million which is the net effect of a $2.6 million Congressional reduction offset by the transfer of $0.8 million due to the redistribution of ROS funding. The impact of this reduction was to eliminate propulsion and related research activities applicable to exploration missions. Research efforts in advanced propulsion concepta were also consolidated to one field center.

Materials and Structures Research and Technology has sustained a total reduction of $2.5 million. Thia includes $3.2 million of hypersonic funding reallocated to the Aeronautics Research and Technology base, a general reduction of $0.5 million offset by the transfer of $1.2 million due to the redistribution of ROS funding.

Space Flight Research and Technology reflects a net reduction of $3.3 million, which consists of a Congressional reduction of $1.2 million, a realignment of $2.5 million to the In-Space Technology Experiments program to enhance industry/university experiments, offset by the transfer of $0.4 million due to the redistribution of ROS funding. This reduction resulted in the postponement of the Modal Identification Experiment (MIE) and will significantly reduce the number of new experiment propoaels to be funded for Phase A studies.

The Systems Analysis program has increased by $0.2 million, which is the net effect of $0.4 million of hypersonic research and technology funding reallocated to the Aeronautics Research and Technology base offset by the transfer of $0.6 million due to the redistribution of ROS funding.

The University Space Research program has not changed.

Information and controls research and technology has been reduced by $3.8 million. This is the result of a Congressional reduction of $4.0 million with impacts in such areas as controls technology, data management, and software verification efforts. In addition, $0.3 million hypersonic research and technology funding was reallocated to the Aeronautics Research and Technology base offset by the transfer of $0.5 million due to the redistribution of ROS funding.

Human support research and technology reflects a net increase of $1.1 million. This is a result of a transfer of $1.0 million due to the redistribution of ROS funding and a $0.1 million increase for human factors engineering activities.

The Space Communications Research and Technology program received a total reduction of $2.3 million, which includes $3.2 million as part of the Congressional reduction, $0.1 million which was reallocated to the ROS in the Aeronautics program, offset by transfer of $1.0 million due to the redistribution of ROS funding.

The In-Space Technology Experiments program increase of $2.5 million is the result of a Congressional reduction of $0.2 million, offset by a realignment of $2.5 million from space flight research and technology to enhance industry/university involvement in this program, and $0.2 million due to the redistribution of ROS funding. The realignment allowed the hardware development of existing industry and university experiments to stay on schedule and allowed the solicitation of new proposals for experiments to be carried out by graduate students in the aerospace engineering disciplines.

BASIS OF FY 1994 ESTIMATE

The Aerothermodynamics program supports the development and application of analytical and experimental capabilities to understand the complex, hypervelocity flow environment in which a vehicle operates during ascent, entry, and maneuvering in the Earth and other planetary atmospheres. The program also includes the conduct of analytical and experimental research to advance the technology of vehicle design for aerothermodynamic efficiency. Program emphasis in FY 1994 will center on concepts for advanced manned launch systems re-entry vehicle design analysis and experimental verification and on developing an improved understanding of chemical and radiative nonequilibrium flow phenomena and on low density flows. This physical understanding is critical to improving the computational design tools necessary to reduce vehicle design risk and uncertainties.

In FY 1994, the Space Energy Conversion progrsm will continue technology development that will meet the needs of next-generation spacecraft, both government and commercial. Demonstration of long-lived, advanced common preasure vessel and bipolar Ni-H2 batteries and regenerstive fuel cell storage systems for potential upgrades for space platforms will also be under way. Thermovoltsic power converters snd alkali metal thermoelectric conversion systems aimed at deep space science applicstions will have been demonstrated. Integrated, environmentally durable, photovoltaics/battery/power management systems combined with electric propulsion for near-Earth space applications, including commercial satellites and Earth observing satellites, will be defined and technology programs with industry will be initiated. A joint effort with industry to insert electromechanical actuators for thrust vector control in commercial launch vehicles will be near completion. Power integrated circuits that substantially reduce parts count snd size while increasing reliability and performance in deep space vehicles will be transitioning to flight. A program to produce wide temperature range electronics thst will benefit deep spsce missions where extreme temperatures are encountered will yield products with additional applicability to both aeronautics and automotive applications.

In FY 1994, the Propulsion program will continue to conduct and support technology development snd insertion efforts critical to the maintensnce of U.S. competitiveness in the space propulsion arena. Some of the significant technical milestones which will be schieved are the validation of "zero-g" water vaporizer concepts on orbiter-tended propulsion systems, validation of structural integrity of a 8kg/5kW class ion thrusters for repositioning and planetsry applications, and the demonstration of Earth and space storsble engines capable of achieving 330-345 seconds of specific impulse for apogee and planetary applications.

The Materials and Structures program will continue to focus on extended spsce durability and environmental effects, lightweight structures for space systems, and technology to enable the development of large space structures. Continued evaluation of materials and coating systems from the Long-Duration Exposure Facility (LDEF) will provide a baseline for assessing stability and long-term durability of materisls, coatings, solar cells snd other related space systems in both low-Earth orbit and geosynchronous Earth orbit. Individual snd synergistic space environmental effects (such as radistion and atomic oxygen effects) on materials will be assessed using degradation models to describe environmental interaction. Computational chemistry will be used to develop data bases for properties of polymers and to model material interaction phenomena on the molecular level. Advanced materisls development will focus on very high temperature ceramic mstrix composites for thermal protection systems.

Advsnced materisls and structural concepts will be explored for integral cryogenic tanks and thermal protection systems, including advanced metallic and composite cryogenic tank concepts and durable, woven ceramic thermal protection systems, for future space vehicles. Reusable rigid insulation systems for 3000+°F performance will be demonstrated. Design concepts, design tools, lubrication methods and sccelerated test procedures for reliable, long-lived space mechsnisms will be developed. Space environment data and effects on materials and space systems will be developed, which will result in more resistsnt and durable

materials and material systems, such as films and coatings. Progress will be made toward developing advanced materials, fabrication and structures technology to reduce cost and improve the performance and reliability of future launch vehicles; and support for advanced concepts of optimization and sensitivity analysis which will be combined with disciplinary analysis methods for efficient synthesis methodology applicable to Space Station of space structures and antennas. In FY 1994, smart materials and adaptive structures will be explored to tap the potential of this technology in adapting, controlling, pointing, and vibration reduction of interferometer-like structures, space platforms for Earth or space observations, and long truss-like structures for space observations or support structures.

The Information and Controls program supports applied research in computer science, sensors, photonics, controls, guidance, automation, and robotics. In the computer science area, the focus is on access to and management of very large scientific data sets; software technology transfer to improve Shuttle operations; software engineering tools for generating very complex and very reliable software; and innovative, but potentially highly effective, computational approaches such as fuzzy logic controls. Sensor research will continue to concentrate on development of solid-state laser materials for enhanced atmospheric science, ranging and altimetry, and other remote sensing applications. Photonic research will emphasize device development in opto-electronic integrated circuit technology for spaceborne systems, such as autonomous landing and optical computing and sensor and processor technology transfer for Space Shuttle Main Engine (SSME) testbed plume analysis. Artificial intelligence efforts will include machine learning, distributed diagnostic systems capable of model-based, as well as experimental reasoning, and embedded real-time systems for scheduling, control and diagnostics. In telerobotics, the program will support academic research on mobile planetary robotic systems, micro-rovers, free-flying telerobotics systems and multiple interactive robotic systems. In the controls and guidance area, emphasis is being placed on the development of analytical tools for the design of control systems for precision pointing and control sensors and actuators for micro-spacecraft and for avionics systems technology for advanced transportation vehicles. Human factors research will continue development of new technology to model and enhance human performance. Models and data on physical and cognitive capabilities in microgravity will be emphasized. Particular focus will be placed on new methods of presenting visual information via computer-based displays and technology to visualize virtual environments for planetary surface applications.

The Space Communications program will be directed toward NASA and commercial satellite communications needs. This program supports applied research and advanced developments in the areas of digital technology, optical communications and radio frequency communications, and module communications systems. The digital technology area emphasizes research on modulation, coding, and switching up to 1 gigabit per second. The optical communications area is advancing the state-of-the-art in laser transceivers for free-space optical communications. The radio frequency communications area is performing research on high-efficiency monolithic millimeter-wave circuit technology on high-performance electron beam technology for advanced deep-space and satellite communications. In FY 1994 the first Ka-band mobile communications terminal will be completed. The terminal will be used to demonstrate the potential of Ka-band communications for space to ground links.

In the Human Support program, research will continue on developing the first fully integrated, closed life support system capable of providing air and water for human consumption during space missions utilizing wastes generated from human metabolic processes and other onboard processes. Sensor research will continue to develop and produce chemical sensors and microbial sensors for utilization in the component and system level control system. Specific requirements for, and development of these control systems will also be initiated in FY 1994. Research to establish new concepts and develop effective chemical processors which will convert waste products into consumable air and water will also be initiated.

In FY 1993, the In-Space Technology Experiments (IN-STEP) program was transferred into the research and technology base. This transfer has resulted in more flexibility in determining experiment feasibility, definition, and development of the hardware/software for the space validation of new technologies. The experiments in this program will continue to provide flight validation of technologies developed in industry or universities, while the continuation of the Space Flight Research and Technology program provides for technologies developed in the NASA centers and the Jet Propulsion Laboratory (JPL). In FY 1994, both programs will continue the flight testing of enabling and enhancing technologies which require the actual space environment for validation. Flight data obtained from in-space research and experimentation will be used to validate and update analytical models, prediction techniques and ground test methods. The program activities support the identification, definition, design, fabrication and flight certification of future in-space experiments which will use the Space Shuttle, expendable launch vehicles and Space Station as platforms.

Specific milestones for FY 1994 will include the launch of five small experiments on a common Hitchhiker carrier in the Shuttle bay. This will support the measurement of the spacecraft glow phenomena, the collection of data on the freeze-thaw behavior of molten salts (which are needed for the design of thermal energy storage systems), the validation of a water electrolyzer in space, the measurement of solar cell arcing under high voltage conditions and an advanced space radiation measurement device. Results of these experiments will serve to aid in the design of space platforms and other spacecraft. The Lidar In-Space Technology Experiment (LITE) will be launched verifying the technology readiness of using a Lidar, including a solid state laser, in space for observing critical atmospheric conditions. The feasibility studies of the approximately fifty experiments selected in FY 1993 will have been completed and the most promising of these experiments will be selected to continue into the definition and preliminary design phase.

The Systems Analysis program supports the development of analytic tools and data bases required to perform engineering tradeoff studies in order to prioritize and integrate multidisciplinary sets of technology options. This effort is closely coordinated with the spaceflight mission program offices to identify the technology requirements for their future mission concepts and technology opportunities for enabling new and improved future missions. In FY 1994, the emphasis of the transportation systems effort will be on launch vehicle concept design studies to assess technologies for the next generation of manned launch vehicles and nuclear electric propulsion for cargo and piloted space transfer vehicles. Technology options to be studied

address staged and single-stage-to-orbit vehicles, horizontal and vertical takeoff and landing vehicles, rocket and airbreathing vehicles, and combined engine concepts. For spacecraft systems, efforts will focus on conducting studies on technologies for the next generation of astrophysics observatories, understanding the potential of miniature spacecraft and micro-science instruments for future Earth and planetary science, and studying the critical technologies necessary for enabling the projected data rates of future science missions.

The University Space Research program is to enhance and broaden the capabilities of the Nations's engineering community to participate more effectively in the U.S. civil space program. In FY 1994, support will continue for the two program elements: the University Advanced Space Design program, which funds advanced systems study courses at the senior level; and the University Space Engineering Research Center program, which supports interdisciplinary research centers. In FY 1994, emphasis will be on maintaining the eight incumbent university space engineering research centers at their planned funding level and encouraging efforts to increase non-NASA funding support and interactions.

BASIS OF FY 1994 FUNDING REQUIREMENT

CIVIL SPACE TECHNOLOGY INITIATIVE (CSTI) PROGRAM

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Operations	36,848	--	--	--
Transportation	27,754	--	--	--
Science	18,346	--	--	--
Space science technology	--	36,700	17,308	33,900
Planetary surface technology	--	22,000	17,314	3,200
Transportation technology	--	42,400	29,085	36,400
Space platforms technology	--	24,600	26,928	23,700
Operations technology	--	32,500	23,981	40,200
Total	82,948	158,200	114,616	137,400

OBJECTIVES AND STATUS

In FY 1993, the CSTI program was restructured to more clearly address the technology needs for high priority civil space missions to focus on research in five thrust areas: space science, planetary surface, transportation, space platforms, and operations. The CSTI program will support many critical technology efforts that are essential to accomplishing our future space goals and will contribute to ensuring U.S. preeminence in research and technology. The following discusses the CSTI program thrusta.

The space science technology thrust is providing technology for future space science missions. The science sensing area consists of three elements: direct detectors, submillimeter aensing, and laser aensing. The observatory systems area consists of two elements: coolers and cryogenics, and micro-precision controls/structure integration. These technologies have application to the Earth Observing System (EOS) and future candidate missions in astrophysics, space physics, and other disciplines. Infrared detector arrays are critical for a variety of space science applications including observations of the Earth's surface and atmosphere, highly sensitive observations of stars and interstellar dust clouds, and broadband observations of the infrared portion of the sun's spectrum. To meet these observation needs, the direct detector element has developed a number of promising technologies to the point where they can be thoroughly evaluated.

and the most promising approaches selected for further development. Submillimeter wavelength observations are used to identify the chemical make-up of the upper atmosphere of the Earth, as well as interstellar gas clouds. Previous technology efforts led to the 205 GHz instrument currently flying on the Upper Atmosphere Research Satellite (UARS) which is observing gasses critical to the Earth's ozone cycle, and the ground-based testing of instruments at frequencies up to 600 GHz. Space-based lasers provide the best approach to provide the global measurements of the Earth's winds, a critical measurement to improve climate modeling and weather prediction. Previous laser sensing element efforts have led to the breadboard demonstration of carbon dioxide gas lasers for the EOS Laser Atmospheric Wind Sounder (LAWS). Recent efforts have demonstrated several promising, solid-state lasers that could reduce the size and complexity of the LAWS instrument. These solid-state lasers will be evaluated on a solid-state Doppler lidar test-bed. Many sensitive science instruments require mechanical cooling to reduce noise and increase mission life. The coolers and cryogenics element has developed two competing designs for two-stage, Stirling cycle mechanical coolers that will provide cooling to 30 degrees Kelvin. These designs will be built, tested, and evaluated. In addition, several control approaches have been demonstrated that reduce the vibration of current, single-stage coolers. Many science missions require highly precise, vibration-free structures to obtain the required measurements. The Micro-Precision Controls/Structure Integration program is developing the techniques for the design and development of these structures. Although the focus is on optical systems (both filled apertures and interferometers), these techniques have application to other missions such as low vibration, microgravity missions. Optical modeling developed under this program was used to evaluate the "prescription" needed for the Hubble Space Telescope (HST) repair mission, and precision actuator technology developed by this program has been selected for use in the HST repair mission. In addition, this element has demonstrated on a ground test-bed a unique, three-layer control approach to provide highly stable optical paths for space structures.

The planetary surface technology thrust includes programs that are essential for robotic and human exploration of the solar system. In FY 1993, work was begun to develop a microrover to be carried on the proposed MESUR Pathfinder mission to Mars. This activity has developed a complete set of design requirements and identified and assessed many of the components needed for the rover. The rover design is based on the Rocky IV rover which was modified and extensively tested by the Jet Propulsion Laboratory (JPL) this year. Two major milestones in FY 1993 will be a preliminary design review and a non-advocate review currently scheduled for the third quarter. Work also continued on developing technology for space nuclear power systems. In FY 1992, a complete 12.5 kWe Stirling cycle power conversion system was fabricated for operation at 950° K. Initial testing in FY 1993 has shown this system to perform to specifications. Fabrication of a long-term test system will be completed in FY 1993 for operation at 1050° K, the design condition for use with an SP-100 space nuclear reactor power system. In FY 1993, NASA will work with the Department of Energy on the SP-100 program. During FY 1992, a major accomplishment was demonstrating the operation of an engineering model of the thermoelectromagnetic primary coolant pump and verifying the compatibility of the coolant loop with liquid lithium coolant.

The transportation technology thrust is primarily concerned with providing the technology needed for future major transportation improvements. The overall goal of the transportation technology thrust is to develop and validate technologies that will substantially improve safety margins and reliability, increase system availability, reduce life-cycle costs, and provide new capabilities for current and future space transportation vehicle systems. In FY 1993, additional emphasis is being placed on facilitating the transfer of these emerging technologies to the commercial space sector through cooperative activities with industry. The transportation thrust consists of two major areas: (1) Earth-to-orbit (ETO) technology and (2) space transportation technology. The ETO area includes research on propulsion system component and subsystem technologies, integrated health monitoring/condition monitoring technologies, design tools, and low-cost manufacturing processes for the next generation of expendable and reusable space transportation systems. Significant technical accomplishments in FY 1992 included in the ETO area include: demonstration of casting technology for a one piece main combustion chamber (MCC) and fabrication technology for a low-cost cooling liner; and adoption of an optical plume analyzer on the Stennis test stands and the testing of an advanced ceramic bearing system that meets the original Shuttle engine goals which are approximately 20 times that which is currently being realized with the existing bearings. In cooperation with industry a small scale version of a low cost fuel injector and improved bearing system were tested at the Lewis Research Center (LeRC). In FY 1993 tests of a larger combustion unit with the low-cost injector and a prototype turbopump with the improved bearings will be tested at the LeRC and Stennis Space Center (SSC), respectively. The space transportation area also incorporates two space propulsion elements: space-based engines and nuclear thermal propulsion. This research includes validating system-level technology for moderate-thrust, expander cycle liquid oxygen/liquid hydrogen chemical engines. The goal is to provide the technology base for the next generation of high-performance upper stage engines. Technology for high-power nuclear thermal propulsion systems which could substantially reduce the mass required in low-Earth orbit and substantially reduce the trip time associated with exploration missions will be reduced to include only systems trade studies.

The space platforms technology thrust is primarily concerned with providing the technology needed for future space platforms. This thrust seeks to provide technologies for the following mission classes: unmanned Earth orbiting platforms in low-Earth orbit or geosynchronous Earth orbit (including technology transfer to commercial satellites), manned Earth orbiting platforms, and deep-space platforms. The goals of this thrust are to enable reductions in launched weight through spacecraft mass reductions, increased spacecraft lifetimes, increased maintainability, and decreased logistics resupply needs. The achievement of these goals will enhance the performance of both government and commercial spacecraft. Ongoing efforts include the Platform Structures and Dynamics program, previously supported by the Control/Structures Integration (CSI) program, and the Solar Dynamics program. The platform structures and dynamics effort is focused on advancing state-of-the-art technologies to enable the precision control of future space structures that support sensitive science instruments. Another goal of this program is to focus on the control requirements

of future manned space platforms. The Solar Dynamics program is working toward the ground demonstration of a 2 kilowatt integrated solar dynamic system. An initiative begun in FY 1993 provides support for advanced technology insertion into the early planning for the Pluto Fast Flyby Mission and the first Earth probe missions in order to reduce cost and schedule while greatly enhancing performance. In FY 1992, the CSI benefits study for advanced Earth observing spacecraft was completed with identification of a number of important benefits to these spacecraft. Closed-loop testing of the CSI controllers on the Space Shuttle Manipulator Arm was successfully completed. The solar dynamic group test program began in FY 1992 with a successful completion of the system requirements review and the awarding of the contract for the test hardware. In FY 1993 advanced spacecraft hardware (sensors, structures) and software will be assembled for the preliminary design phase of future missions such as the Pluto Fast Flying and the Thermosphere, Ionosphere, Meosphere Evergetic and Dynamics (TIMED) Earth probe missions.

The goal of the operations technology thrust is to develop and validate technologies to reduce the cost of NASA operations, improve the safety and reliability of those operations and enable new, more complex, activities to be undertaken. For the ongoing FY 1993 program, specific program areas include two elements: (1) automation and robotics and (2) information and communications. The automation and robotics area will develop artificial intelligence systems to support mission operations and expert data analysis. In FY 1992, the introductions of advanced scheduling technology has significantly improved the ability to schedule Shuttle processing, while saving hundreds of thousands of dollars for each launch. Operation of the SKYCAT program enabled cataloging of the Palomar Sky Survey two orders of magnitude faster than previous techniques. In early FY 1993, the Dante and Rocky IV robotic vehicles were developed and demonstrated, with Dante being deployed to the Antarctic in December 1992. The program also addresses long-term issues associated with control of multiple knowledge-based systems, the management of uncertainty in complex systems, and machine learning. In addition, this area will evaluate robotics systems to support both ground processing and in-space activities. Telerobotic devices to perform a number of inspection tasks required for Shuttle processing will be developed. Also, demonstration of ground-based models of in-space activities for future application to telerobotics tasks will be supported. The information and communications area addresses the high-priority needs across NASA for more capable space processors and systems, more effective software development, and advanced communications capabilities. In particular, the program will concentrate on space-qualifiable computers, special processors, and memory systems, and will investigate architectures to support space data systems. In FY 1993, data compression techniques and chips were transferred to both space and commercial applications, and characterization of space computers led to the selection of onboard computers for the Cassini mission.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The total FY 1993 CSTI budget was reduced $43.6 million, which is the net result of a Congressional reduction of $46.5 million partially offset by a transfer of $2.9 million due to the redistribution of Research Operations Support (ROS) funding. Support for research activities, some of which are already

funded at a marginal level, will be confined to addressing only a few of the high priority user office needs. Many technology tasks planned for FY 1993 will be eliminated or deferred. Changes by technology thrust are as follows:

Space Science Technology

The Space Science Technology program reflects a net decrease of $19.4 million which reflects a decrease of $19.7 million to accommodate the Congressionally-directed reduction and a transfer of $0.3 million due to the redistribution of ROS funding. Reductions in science sensing total $11.6 million and reductions in observatory systems activities total $8.1 million, offset by ROS transfers of $0.3 million. This significantly reduces planned activities in microprecision controls and structures interaction, as well as research efforts in high-energy detector technology, laser metrology, and coolers and cryogenics.

Planetary Surface Technology

In planetary surface technology, the net reduction of $4.7 million, which is the net result of $5.0 million Congressional reduction and $0.3 million ROS transfer. This will result in the termination of all focused research efforts in human support technology ($7.0 million). Within planetary surface technology funding has been redirected to initiate studies leading to development of a rover to be flown on the MESUR/Pathfinder mission ($2.0 million). This rover will be instrumented to conduct technology experiments in mobility navigation and system integration for science data collection.

Transportation Technology

Transportation technology has been reduced by a total of $13.3 million, which is the net result of $14.8 million Congressional reduction, partially offset by a transfer of $1.5 million due to the redistribution of ROS funding. This net reduction has been accommodated by reducing Earth-to-orbit transportation by $9.0 million and space transportation technology efforts by $4.3 million.

Space Platforms Technology

In space platforms technology, funding has been increased by $2.3 million. Funding for technology efforts in platform structures and dynamics has been reduced by $6.0 million and platform power and thermal systems has been decreased by $2.0 million. These reductions have been offset by increased funding to initiate analytical and experimental efforts toward innovative concepts in lightweight planetary spacecraft ($5.0 million) and Earth observing spacecraft ($5.0 million) and a transfer of $0.3 million due to the redistribution of ROS funding.

Operations Technology

Operations technology funding has been reduced by a total of $8.5 million, which is the net result of $9.0 million Congressional reduction, partially offset by a transfer of $0.5 million due to the redistribution of ROS funding. This will be accommodated by a reduction of $3.1 million in automation and robotics and $5.4 million in space data systems and will include termination of the development of the spaceflight optical disk recorder.

BASIS OF FY 1994 ESTIMATE

In the space science technology thrust for FY 1994, the direct detector element activities will continue the development of large area, 65 degree Kelvin operating temperature detector arrays in the 12- to 18-micron region of the electromagnetic spectrum, pursuing the three most promising approaches developed in FY 1993. In addition, this element will develop highly sensitive, low operating temperature arrays in the 30- to 300-microns region using blocked impurity band phenomena. The submillimeter element will provide the initial laboratory demonstration of a heterodyne receiver system operating near 800 GHz for astrophysics mission applications. The laser element will complete the development a ground test-bed to demonstrate solid-state Doppler lidar for wind measurements, and will continue developing solid-state lasers for evaluation on the test-bed. The coolers and cryogenics element will complete the brass-board model of the two-stage, 30° Kelvin Stirling cycle cooler, and will begin environmental testing of this cooler. The micro-precision controls/structure integration element will complete phase one of the micro-precision interferometer testbed, as well as the design of a 6-axis isolation system, leading to the demonstration in FY 1995 of vibration attenuation to the sub-micron level.

In FY 1994 the planetary surface technology program will focus on developing technologies primarily in support of robotic science missions. Specifically, a program will be initiated to develop advanced rover technology to further support the needs for advanced science rover technology. In FY 1994 this effort will focus on issues such as advanced mobility systems, autonomous navigation and systems integration. The joint NASA/Department of Energy (DOE) SP-100 program will be terminated at the end of FY 1993.

The transportation technology thrust is concerned with providing the technology needed for future transportation systems. The overall goal of the transportation technology thrust is to develop and validate, through industry/government/academic partnerships, innovative technologies that will provide new capabilities and will enable the development of future space transportation systems with reduced life-cycle costs, substantially improved safety margins and reliability, and increased system availability, ensuring U.S. commercial competitiveness and world leadership in exploration and utilization of space. In FY 1994, additional emphasis will continue to be placed on cooperative activities with the expendable launch vehicle industry. Significant FY 1994 milestones include: (1) a large scale firing of an integrated cast chamber/cooling liner main combustion chamber (MCC) which builds upon FY 1993 plans to fabricate several

integrated cast chamber/cooling liner MCC's for testing and evaluation. This technology is projected to lead to a seven-fold reduction in fabrication costs, a reduction in MCC welds from 96 to 4 and reduction in fabrication time from approximately three years to six months and (2) if FY 1993 tests of a larger combustion unit with the low-cost injector and a prototype turbopump with the improved bearings at the LeRC and SSC are successful. FY 1994 plans include consideration of large scale testing on complete system employing both of these, as well as other technology advances, using both cryogenic (Hydrogen/Oxygen) and hydrocarbon fuels.

In the space platforms technology thrust, platform structures and dynamics will focus on developing and applying controls/structures integration techniques to space platforms and to developing advanced platform structures concepts. Ground-based hardware testbeds, including both in-house and non-NASA guest investigator activities, will continue to be supported. In FY 1994, laboratory experiments will be completed on the simultaneous pointing of multiple, independent science sensors using a platform-like ground test bed. Also, the ground test bed of a space station pre-integrated truss will be completed and modal testing will begin. The platform power and thermal systems will focus on developing and demonstrating key technologies for increased power at reduced costs for future Earth-orbiting spacecraft, low-Earth orbit (LEO), or geostationary Earth orbit (GEO) science spacecraft, and future astrophysics missions. In FY 1994, the fabrication and testing of the components of the solar dynamic ground test system will be completed and installation of the system will be initiated. The Advanced Technology Insertion program for the Pluto Fast Flyby and TIMED science missions will continue with the initial fabrication of testbeds to check out advanced instrument and platform technologies. These testbeds will permit the selection of the best advanced technologies that will enable fabrication of lighter weight, lower cost spacecraft.

In the operations technology thrust, the FY 1994 program will focus on supporting automation and robotics and space data systems. The automation and robotics portion will focus on advanced teleoperation, robotics and supervisory control (telerobotics) to be applied to problems in launch processing, on-orbit operations and processing, and science operations. During FY 1994, the program will demonstrate robotic inspection capabilities with contact and manipulation; demonstrate an intra-vehicular activity (IVA) robot with collision avoidance; and demonstrate spacecraft repair with communications time delay. The artificial intelligence program will focus on providing real-time, fault-tolerant control for flight critical systems and on developing, testing and validating increasingly complex autonomous systems. This will start with automation of a single critical function and progressing to coordinated control of multiple critical functions. This includes increasingly productive assistance to mission operations, moving from single function applications toward multiple, cooperating applications, automated engineering analysis tools, autonomous onboard diagnostic systems, and life-cycle knowledge capture systems. The intelligent aid named PI-in-a-Box is scheduled to fly on the Shuttle in October 1993 and in 1994 a prototype diagnostic and control system for the Advanced X-ray Astrophysics Facility (AXAF) will be demonstrated. The space data

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systems efforts will continue to focus on developing and demonstrating new onboard processing and data storage capabilities for a range of future space and Earth science, exploration and infrastructure systems. Preliminary design of experimental onboard digital processors and correlators will be continued. The program is working towards demonstration of a high speed gallium arsenide pipeline processor in FY 1995, and a multi-channel 500 MH_2 auto correlation spectrometer will be tested during FY 1994.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1994 ESTIMATES

BUDGET SUMMARY

OFFICE OF ADVANCED CONCEPTS AND TECHNOLOGY

COMMERCIAL PROGRAMS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate	Page Number
		(Thousands of Dollars)			
Technology transfer.....	32,500	31,700	29,495	26,900	RD 8-2
Commercial use of space.....	115,100	139,900	134,879	145,100	RD 8-7
Total.....	147,600	171,600	164,374	172,000	

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1994 ESTIMATES

BUDGET SUMMARY

OFFICE OF ADVANCED CONCEPTS AND TECHNOLOGY

TECHNOLOGY TRANSFER

SUMMARY OF RESOURCES REQUIREMENTS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Civil systems	13.000	6.500	6.500	3.400
Dissemination	5.800	5.900	4.695	5.600
Network	6.500	9.500	9.500	9.000
Applications	7.200	9.800	8.800	8.900
Total	32.500	31.700	29.495	26.900
Distribution of Program Amount by Installation				
Johnson Space Center	4.546	2.380	2.495	905
Kennedy Space Center	320	425	380	560
Marshall Space Flight Center	970	877	1.000	1.483
Stennis Space Center	750	570	785	635
Goddard Space Flight Center	1.452	1.460	1.298	1.775
Jet Propulsion Laboratory	640	600	675	925
Ames Research Center	763	412	1.225	1.045
Langley Research Center	1.083	620	527	996
Lewis Research Center	775	716	880	1.205
Headquarters	21.201	23.640	20.230	17.371
Total	32.500	31.700	29.495	26.900

OFFICE OF ADVANCED CONCEPTS AND TECHNOLOGY — TECHNOLOGY TRANSFER

OBJECTIVES AND JUSTIFICATION

The NASA Technology Transfer program is designed to strengthen the national economy and industrial productivity through the transfer and application of aerospace technology resulting from NASA's R&D programs. To accomplish this objective, NASA has established and operates a number of technology transfer mechanisms to provide timely access of useful technologies to the private and public sectors of the economy. Almost every part of U.S. industry is affected by the technology transfer process, especially in such areas as automation, electronics, materials, and productivity. In the public sector, medicine, rehabilitation, transportation and safety are areas in which aerospace technologies have been especially beneficial. The specific objectives of the program are:

- To accelerate and facilitate the application of new technology into the commercial sector, thus shortening the time between the generation of advanced aeronautics and space technologies and their effective use in the economy;

- To encourage multiple secondary uses of NASA technology in industry, education, and government, where a wide spectrum of technological problems and needs exist;

- To develop applications of NASA's aerospace technology, including its unique facilities, to address priority non-aerospace needs of the Nation.

OBJECTIVES AND STATUS

The Technology Transfer program promotes the transfer of technology developed in NASA's R&D programs to the public and private sectors of the U.S. economy. A network of Regional Technology Transfer Centers (RTTCs) and NASA installation Technology Transfer offices form the core of the Agency's technology transfer efforts. Technologies developed for the Nation's aerospace program are reused or re-engineered to provide new products and processes in the areas of transportation, energy, medicine, public safety, and consumer goods. The goal of the program is to broaden and accelerate the technology transfer process to realize additional dividends on the national investment in aerospace research. This will also help the United States to maintain its competitive position in the international marketplace.

Activities in FY 1993 include:

- Completing the state and local government linkages to round out the "grid" of the national technology transfer network.

- Maintaining the nationwide technology transfer network to support cooperative efforts with the Federal Laboratory Consortium, state-sponsored business and technical assistance center, and Small Business Development Centers. These linkages enable the Technology Transfer program to keep pace with growing industrial demand for information and technology transfer services.

- Improving the technology transfer capabilities of the Technology Transfer offices at the NASA Field Centers through more efficient and effective methods of documenting and archiving new technology developments; increasing their capabilities to "broker" cooperative agreements between their laboratories and commercial entities; and extending their outreach capabilities within their geographical environments to assist in their economic development efforts.

- Promoting awareness of NASA's Technology Transfer program and resources available to the public and private sector through a broad array of communications vehicles, such as: the Tech Briefs publication; Spinoff magazine; seminars and conferences (e.g. Technology 2002 which reached an audience of over 6,000 and featured 200 exhibits), etc.

- Continuing and completion of the development of the AdaNET repository and library, and implementing a pilot to test the applicability of reusable software components to NASA's software development needs.

- Continuing implementation of the National Technology Transfer Center (NTTC) at Wheeling Jesuit College.

- Strengthening and enhancing NASA's dual-use (NASA/commercial) research programs through the continuation of the Joint Sponsored Research program and the establishment of two small pilot NASA (field center based) Technology Commercialization Centers.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The title and structure of the Technology Transfer (previously Technology Utilization) program has been slightly modified from the FY 1993 Congressional submission. The adjustments were undertaken to modernize and clarify the display of the Technology Transfer budget. The primary change is the centralization of the programs for collection/evaluation/publication of technology information under the "Dissemination" element. The "Network" program is now more clearly defined as those activities which use and/or manage technology information (e.g. RTTCs), with the "Applications" program including only technology application engineering projects.

The overall Technology Transfer program was reduced by $2.7 million as a result of the reduced FY 1993 appropriation. The Civil Systems program, which includes the AdaNET and NTTC projects, remains unchanged. Funding for the Dissemination program is reduced due to the elimination of funding for further development of the Technology Utilization Network System (TUNS) and the elimination of funding for centralized technology evaluations. Funding for the Network activities, which primarily includes resources for the RTTCs remains unchanged. The Applications program is reduced due to the elimination of all planned new initiative technology applications project funding. These adjustments are offset by a $0.5 million increase due to the redistribution of Research Operations Support (ROS) funding.

BASIS OF FY 1994 ESTIMATE

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Civil systems.....	13,000	6,500	6,500	3,400

The NTTC will continue to facilitate the transfer of federal technology to the private sector through operation of a national gateway/clearinghouse that links "technology inquirers" with federal laboratories. It will also fully establish a technology transfer training program for industry and government. The NTTC will actively foster teaming between federal laboratories and industry as well as state and local governments by acting as a broker in the establishment of cooperative technology transfer projects. The AdaNET software repository/library and a pilot study to test the applicability of reusable software components to meet software development needs will be complete in FY 1993. No AdaNET funding is included in the FY 1994 estimate, as the program is expected to be self-supporting.

Dissemination.....	5,800	5,900	4,695	5,600

Funding for the field center technology transfer offices will be enhanced to provide for increased outreach capability to conduct economic development activities in their geographical regions; increased capability to negotiate cooperative agreements with commercial firms; and increased ability to conduct "in-house" new technology evaluations. Preparation of NASA Tech Briefs magazine and related materials for publication will continue. Circulation of NASA Tech Briefs magazine is expected to reach well over 200,000 by FY 1994 (over 90 percent of whom are corporate managers, engineers or scientists). The Center for Aerospace Information (CASI) will also continue to provide support by responding to general and specific inquiries from public and private sources which request information concerning NASA technological developments and other technology transfer program products and services.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Network.....	6,500	9,500	9,500	9,000

The RTTCs will continue to enhance and extend their state and local government linkages to insure the widest possible provision of technology transfer services to their geographical regions. Operation of both the Computer Software Management and Information Center (specializing in the transfer of NASA software on a cost-recovery basis) and the Technology Applications Center (assisting in the commercialization of space remote sensing technology and dissemination of NASA remote sensing data on a cost-recovery basis) will continue.

Applications.....	7,200	9,800	8,800	8,900

The completion of many ongoing technology application projects is expected by the end of FY 1993. In FY 1994, funding will be available for several "new start" application projects. The review process for these projects will place increased emphasis on funding those projects in which a commercial partner has been identified, or for which a high probability for commercial success has been determined through market analysis.

The Joint Sponsored Research program begun in FY 1992 will also continue to accelerate the development of "dual-use" NASA mission technology that is also of value to the commercial sector.

The NASA field center based Technology Commercialization Centers begun in early FY 1993 will continue to assist commercial firms to develop NASA technology beyond the primary NASA mission use and into the commercial sector.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1994 ESTIMATES

BUDGET SUMMARY

OFFICE OF ADVANCED CONCEPTS AND TECHNOLOGY

COMMERCIAL USE OF SPACE

SUMMARY OF RESOURCES REQUIREMENTS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Commercial applications and enhancements	41.300	44.100	43.957	40.700
Commercial development support	3.300	5.300	5.063	4.100
Commercial transportation	59.100	76.900	74.207	91.100
Communications systems	11.400	13.600	11.652	9.200
Total	115.100	139.900	134.879	145.100
Distribution of Program Amount by Installation				
Johnson Space Center	40.000	53.150	51.819	69.160
Kennedy Space Center	800	1.550	650	1.840
Marshall Space Flight Center	1.100	1.850	1.140	920
Stennis Space Center	4.500	5.100	4.000	5.200
Goddard Space Flight Center	1.300	1.450	1.375	1.516
Ames Research Center	900	700	500	300
Langley Research Center	200	700	235	39
Lewis Research Center	4.500	6.390	3.466	2.512
Jet Propulsion Laboratory	1.500	1.741	991	1.116
Headquarters	60.300	67.269	70.703	62.497
Total	115.100	139.900	134.879	145.100

OFFICE OF ADVANCED CONCEPTS AND TECHNOLOGY — COMMERCIAL USE OF SPACE

OBJECTIVES AND JUSTIFICATION

Objectives of the Commercial Use of Space (CUS) program are to develop opportunities for the expansion of U.S. private sector investment and involvement in civil space activities. The program is designed to:

- Foster close working relations with the private sector and academia that encourage investment in space technology and the use of the *in situ* attributes of space--vacuum, microgravity, temperature and radiation -- for commercial purposes.

- Facilitate private sector space activities through improved access to available NASA capabilities and the development of new high technology space markets.

- Encourage increased private sector investment in the commercial use of space independent of NASA funding.

- Implement and support commercial space policy NASA-wide.

The FY 1994 CUS program will be characterized by increased discipline and balance.

The CUS will use discipline and peer review to select projects and payloads. The CUS experiments program spans a range of promising commercial technologies. CUS expects to rely more heavily during FY 1994 on the scientific and technical expertise within the NASA community for project selection and oversight. Increased reliance on advisory groups will also contribute additional rigor to CUS programs.

The CUS experiment programs strike a balance between their pursuit of both short- and long-term commercial results. Guided by the need to select projects with strong commercial prospects, CUS programs support experiments likely to begin producing commercial results by the middle of the decade and well into the early years of the next century.

The CUS transportation programs have evolved in response to commercial customers' needs to access space in a systematic manner. The CUS investigators require more flight opportunities than are available through traditional NASA sources. The CUS initiated programs such as the Commercial Middeck Augmentation Module (CMAM) and the COMmercial Experiment Transporter (COMET) to respond to requirements for crew-assisted and/or long-duration flight.

To balance its transportation program and to optimize access to space, CUS relies on a series of test bed transportation systems, like KC-135 flights and sounding rockets. These systems provide additional short-duration microgravity flight opportunities. They provide low-cost opportunities for investigators to evaluate concepts and flight hardware. In addition, CUS expects to be a primary user of the Space Station, thereby providing commercial investigators a long-duration laboratory environment.

Both the CMAM and the COMET are proceeding successfully. Both systems are approaching their first flights in FY 1993. Follow-on flights for both systems are scheduled for FY 1994. The commercialization prospects for both systems are uncertain but each will provide economical flight alternatives for commercially-sponsored payloads.

NASA's goal of expanding opportunities for U.S. private sector investment and involvement in civil space and space-related activities is pursued through a variety of interrelated programs. Through cooperative agreements and partnerships via the Centers for the Commercial Development of Space (CCDS), CUS will increase the amount of space-related research conducted by the private sector, the number and type of NASA and private sector facilities available for space use, and the private sector awareness of opportunities to use NASA's terrestrial and space-based facilities for commercial research.

The CCDSs, a network of universities and private sector enterprises, are the primary mechanisms that CUS uses to achieve its space commercialization objectives. Seventeen CCDSs conduct applied research in fields with promising business prospects, including the fields of space propulsion, biotechnology, materials processing, space remote sensing, and communications. The CCDSs are:

1. Space Automation and Robotics Center, located at the Environmental Research Institute of Michigan, in Ann Arbor, MI. Focus: developing critical technology through demonstration flights for commercial space satellite servicing, retrieval and repair; developing robotics technology for automated laboratory activities in space and focused terrestrial applications of robotics technology.

2. Wisconsin Center for Space Automation and Robotics, located at the University of Wisconsin. Focus: to conceive, demonstrate and stimulate space and terrestrial commercialization of technology developed for space experiment automation, plant growth and life support systems, and the development of lunar fuel sources.

3. Center for Mapping, located at Ohio State University. Focus: to develop and integrate different capabilities into commercial opportunities for the suppliers of both space remote sensing systems and information systems.

4. Space Remote Sensing Center, a Division of the Institute for Technology Development, located at the John C. Stennis Space Center, MS. Focus: providing commercial technology applications development of satellite remote sensing, image processing, and geographic information systems.

5. BioServe Space Technologies, located at the University of Colorado at Boulder. Focus: developing technologies in the areas of biomedical isomorphisms, controlled ecological life support systems, bioprocessing and bioproduct research, and related hardware development task.

6. Center for Cell Research, located at Pennsylvania State University. Focus: physiological testing, bioseparations and bioprocessing, and equipment and environment design.

7. Center for Macromolecular Crystallography, located at the University of Alabama at Birmingham. Focus: space-grown crystals of biological materials, and developing technology and applications for the space-based material processing of biological crystals.

8. Advanced Materials Center, located at Battelle in Columbus, OH. Focus: multi-phase materials processing research in four technical areas: catalysts; metals and ceramics; polymers; and electronic and optical materials.

9. Center for Commercial Crystal Growth in Space, located at Clarkson University. Focus: developing commercial crystal growth in space and developing a broad spectrum of crystal growth techniques (melt, solution and vapor, theoretical modeling, complementary thermophysical property measurement, and structural and electronic characterization.)

10. Consortium for Materials Development in Space, located at the University of Alabama in Huntsville. Focus: developing commercial materials that benefit from unique attributes of space, and focus on commercial materials, commercial applications of physical chemistry and material transport, and prompt and frequent experiments and operations in orbit.

11. Space Vacuum Epitaxy Center, located at the University of Houston, TX. Focus: exploring R&D and commercial possibilities of thin film growth and materials purification in space.

12. Center for Space Power, located at the Texas A&M University. Focus: applied research relevant to space and related terrestrial power systems and developing industry partnerships to demonstrate technology associated with the commercial use of space.

13. Center for the Commercial Development of Space Power and Advanced Electronics, located at Auburn University, AL. Focus: to identify critical technological impediments to the economic deployment of power systems in space, promote and develop "dual use" technologies leading to new products that meet power generation, storage, conditioning, and distribution needs.

14. Center for Space Transportation and Applied Research, located at the Tennessee Space Institute in Tullahoma, TN. Focus: to develop industry partnerships that contribute to propulsion technologies that are considered prime in achieving basic space flight mission objectives.

15. Center for Materials for Space Structures located at Case Western Reserve University in Cleveland, OH. Focus: to develop and implement opportunities for U.S. industry to explore future materials for space structures that are suitable for being studied, used, or processed in space and that are capable of withstanding the harsh space environment. Promising research areas include polymeric composites, metallic composites, ceramic composites, organic coatings, and metallic coatings.

16. Center for Satellite and Hybrid Communication Networks located at the University of Maryland at College Park, MD. Focus: space-based communications, especially in the context of hybrid networks that integrate terrestrial and extra-terrestrial communications technologies.

17. Center for Space Communications Technology, located at Florida Atlantic University in Boca Raton, FL. Focus: to develop the commercial use of digital transmission techniques for transmitting video, audio and data to the Earth by satellite.

The CUS also manages a commercial remote sensing program through the Stennis Space Center. More than $5.0 million of FY 1994 resources will fund a remote sensing program at Stennis, providing a valuable complement to the experiments programs administered by the CCDSs. CUS expects to complete a targeted commercialization plan for the remote sensing program and to rely more heavily on a new advisory group. The result of the additional management and planning attention will be a better portfolio of projects with near-term commercial prospects. Included among the FY 1994 results will be commercial applications for agriculture, environmental monitoring, and natural resources management. One expected FY 1994 result, for example, will be the Airborne Terrestrial Applications Sensor (ATLAS) system. Attached to the Stennis learjet aircraft, the ATLAS system will begin data collection for environmental monitoring and mineral identification. CUS continues support of the Earth Observations Commercial Applications Program (EOCAP), also at the Stennis Space Center.

The CMAM contract, awarded to Spacehab, Inc., through open competition, involves flight accommodations and associated supporting services. This includes use of the commercially-developed CMAM flight modules and trainers, physical and analytical integration services, training of flight crews, and support to experiment

flight operationa. The CMAM flight modules are pressurized, orbiter-based, mixed cargo carriers designed to augment the orbiter middeck by providing approximately 1100 cubic feet of additional volume for support of crew and payloads. Fifty middeck locker equivalents (MLEs) of payload space can be accommodated on each module. The CMAM is connected to the orbiter through a modified Spacelab tunnel adapter and draws resourcea from the orbiter cabin and cargo bay payload support provisions. Cooling, power, command/data and housekeeping systems (lighting, fire suppression, atmosphere control, status monitoring and crew emergency breathing) are provided. The CMAM is being procured under a lease-tenant arrangement. The first CMAM flight, scheduled for FY 1993, will accommodate payload experiments developed by seven different CCDSs.

The COMET is a fully integrated space transportation and recovery service to meet the needs of the commercial research and development community. This service, with three launches planned for the 1993-1995 time frame, will carry experiments to the microgravity of space and return those integrated into the COMET recovery vehicle. The COMET service module provides basic utilities such as electric power, controlled temperature, orientation, data management and communications while in orbit. The COMET provides flexible payload accommodations for a wide variety of materials and equipment. Each mission will launch a two-part (experiment facility) free flyer which will carry commercial microgravity, communications, and rendezvous and docking experiments into a nominal 300 nautical mile orbit. The recovery vehicle returns to land by parachute after 30 or more days in orbit. Access to the payloads in the recovery system is possible up to six hours before launch, enabling installation of degradable or limited-life materials. The COMET program was established and is being implemented by the Center for Space Transportation and Applied Research (CSTAR) located at the University of Tennessee Space Institute in Tullahoma, Tennessee. The first launch is scheduled for mid-1993.

In order to maintain momentum in Commercial Use of Space (CUS) activities and to encourage an increase in private sector investment in space, NASA will continue to develop methods to facilitate private sector agreements and commitments to pursue commercial opportunities in space. The development of agreements for the use of the Shuttle external tanks and private sector use of U.S. launch facilities reflect this effort.

The Advanced Communications Technology Satellite (ACTS) program will help the U.S. maintain its leadership in the communications satellite market by the development and flight verification of advanced technologies that will enhance the capability of communications satellites. The CUS program is responsible for the management of the ACTS user experiment program. The U.S. user community, consisting of private sector organizations and other government agencies, will develop and execute experiments that will test and evaluate the ACTS technologies under various applications scenarios. The key ACTS technologies include high effective isotropic radiated power; fast-hopping multiple beam antenna; on-board intermediate frequency and baseband switching; Ka-band components; and dynamic rain fade compensation techniques. The ACTS is planned for a Space Transportation System/Transfer Orbit Stage (STS/TOS) launch in 1993.

The Radio Science and Communications Satellite Commercialization program provides technical support for U.S. and NASA interests in international and domestic communications regulatory forums. For example, propagation in the measurements are performed in order to understand and account for the effects of signal propagation in the design and specification of space communications systems. Studies to enable new aatellite applications are conducted.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The CUS program has been reduced by $6.3 million in response to Congressional appropriation action, but is preserving funding for its highest-priority transportation projects and the ACTS experiments program, consistent with Congressional direction, as well as the Wake Shield facility, currently being prepared for a 1994 flight.

The budget reductions in FY 1993 have been allocated among the remaining CUS programs. These include the cancellation of a sounding rocket flight that had been planned for FY 1993; reduction of support to sounding rocket and lower-priority payload development and associated payload integration; a reduction in program support contracts; and reduction of remote sensing projects at the NASA centers. CUS will also terminate a planned research announcement program for ACTS experimenters. These adjustments are offset by a $1.3 million increase due to the redistribution of Research Operations Support (ROS) funding.

BASIS OF FY 1994 ESTIMATE

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Commercial applications and enhancements.....	41,300	44,100	43,957	40,700

The CUS program will utilize FY 1994 resources to design, develop and prepare commercially-sponsored experiments for flight consistent with their current schedules. In collaboration with the CCDS network and with NASA's centers, CUS will continue to pursue an aggressive flight program supporting both near- and long-term commercialization activities. Resources will finance projects and activities across a number of technology areas, including materials processing, life sciences, remote sensing and space infrastructure.

CUS plans to conduct 50 payload tests in FY 1994. Most experiments will fly on the Space Shuttle (middeck or CMAM), and the COMET launch vehicle. Included in the FY 1994 program will be the first flight of the Wake Shield facility, scheduled to fly as an orbiter payload in November 1993. CUS will also use available

NASA aircraft to support remote sensing and other project activities. In addition, CUS will evaluate the potential benefits of future transportation systems and the program will continue the process of planning for Space Station utilization.

The CCDS network of universities will continue as the primary tool for conducting the program's commercial activities and, as in past years, the performance and workloads associated with the Commercial Applications and Enhancements program will directly involve other NASA offices, NASA Centers, other Federal agencies, and private industry. Management of the remote sensing element will continue to rely upon Landsat and the French SPOT, the two current sources of remotely-sensed data for commercial use, as sources for data imaging, analysis, transmission, and for value-added applications.

FY 1994 funding will also support analytical and physical integration required for Space Shuttle payloads flown by the CCDSs and under commercial cooperative agreements. Resources also support Space Shuttle optional services, for which reimbursement is deferred under some Space Systems Development Agreements (SSDAs). The CUS program's current SSDAs are with SPACEHAB, Inc., and Space Industries Partnership.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Commercial development support.....	3,300	5,300	5,063	4,100

The CUS will depend on its support program during FY 1994 to provide systems engineering studies, strategic analyses, and industry trend analyses that contribute to high-quality commercial project selection and management. Headquarters support contracts funded in this line for ADP, graphics, and related services will decline from previous years, consistent with the CUS desire to realign resources to direct program activities.

Commercial transportation.....	59,100	76,900	74,207	91,100
Commercial middeck augmentation module.....	39,000	51,400	51,407	66,500
Commercial experiment transporter	18,000	22,000	22,800	24,600
Sounding rocket	2,100	3,500	--	--

The CUS program's highest-priority transportation projects will be fully supported in FY 1994 -- the CMAM, supporting middeck-class experiments that require crew support, pressurization, late access and early retrieval, and ascent/deacent power; and the COMET, an expendable launch vehicle system providing launch, low-Earth orbit operations, payload recovery, and long-duration microgravity. FY 1994 funding will enable the continuation of both these critical projects.

Although no funds are requested in FY 1994 for the Sounding Rocket program, the failure of an earlier JOUST rocket flight has resulted in a flight insurance reimbursement to the Consortium for Materials Development in Space CCDS. These funds will allow continuation of the program during FY 1994. Moreover, existing contractual arrangements with the service provider allow for the continuation of the Sounding Rocket program during FY 1995 and subsequent.

The CMAM request will support the second and third STS flights scheduled for November 1993 and June 1994, respectively. The FY 1994 COMET request will provide for the second flight, in September 1994, of three scheduled missions under the original procurement. Together, CMAM and COMET will support 29 payload tests during FY 1994.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Communications systems.....	11,400	13,600	11,652	9,200

The CUS program will continue to respond to the emerging commercial research needs of the country's communications industry. A major contributor toward this objective includes the Advanced Communications Technology Satellite (ACTS) experiments program. Commercial interest in the ACTS program is accelerating as the satellite launch date approaches in mid-1993, and terminal development and acquisition will be emphasized in the FY 1994 program. By the start of FY 1994, CUS expects to have well over 50 experimenters working with the ACTS system with the list of experimenters expected to continue to grow.

As in other CUS program areas, a diversified ACTS experiments program is being pursued. CUS expects to complete the activation of eighteen T1-VSAT ground terminals and to conduct related experiments with the U.S. Army and with industry. CUS will complete activation of the Aero-Mobil terminal. It will initiate demonstrations and experiments for Land-Mobil and for Aero-Mobil. Following delivery of high data rate and ultra small aperture terminals, government and industry partners will activate them for an intensive series of experiments.

The ACTS experiments program will also benefit during FY 1994 from the results of a blue ribbon panel review of the ACTS experimenta program which was completed during the first half of FY 1993. The blue ribbon review by a series of non-government experts was consistent with CUS's recent efforts to improve the quality and selection of its payloads and experiments. The intent of the panel review was to contribute to the selection of experiments with the most promising commercial prospects. One of the more promising commercial research areas, according to the panel, would be a series of experiments in support of the aeronautical and aviation industry. CUS intends to keep the ACTS experiments program focused on these and other high-potential areas.

In FY 1994, Communications Systems includes the NASA activities associated with the international Search and Rescue program, which has been previously budgeted and managed under Space Science and Applications. The budget estimate of $1.1 million will continue to support research and development leading to new or additional applications or capability improvements. Search and Rescue program operations remain the responsibility of the National Oceanic and Atmospheric Administration.

Advanced communications and propagation studies activities will be continued in FY 1994 at a reduced level and will support the development of the technical basis for standards development and for regulatory decisions at the national and international level. Propagation studies and measurements will also be sustained at a reduced level to fill voids needed to design new satellite applications for fixed communications, mobile communications, and sound broadcasting.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1994 ESTIMATES

BUDGET SUMMARY FOR AERONAUTICS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate	Page Number
	(Thousands of Dollars)				
Aeronautics research and technology....	788,192	890,200	865,587	1,020,700	RD 9-1
Transatmospheric research and technology.....	4,136	80,000	--	80,000	RD 10-1
Total.....	792,328	970,200	865,587	1,100,700	

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1994 ESTIMATES

BUDGET SUMMARY

OFFICE OF AERONAUTICS

AERONAUTICAL RESEARCH AND TECHNOLOGY

SUMMARY OF RESOURCES REQUIREMENTS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate	Page Number
		(Thousands of Dollars)			
Research and technology base.....	343,297	394,000	436,478	448,300	RD 9-5
Systems technology programs.....	212,122	253,000	280,284	428,900	RD 9-16
Research operations support.....	232,773	243,200	148,825	143,500	RD 9-39
Total.....	788,192	890,200	865,587	1,020,700	
Distribution of Program Amount By Installation					
Jet Propulsion Laboratory.....	2,400	2,500	2,990	3,600	
Goddard Space Flight Center.....	4,100	7,400	6,280	13,600	
Ames Research Center.....	259,000	299,200	286,317	320,000	
Langley Research Center.....	241,000	260,400	263,400	330,000	
Lewis Research Center.....	222,000	257,100	254,300	289,000	
Headquarters.....	59,692	63,600	52,300	64,500	
Total.....	788,192	890,200	865,587	1,020,700	

OFFICE OF AERONAUTICS

AERONAUTICAL RESEARCH AND TECHNOLOGY

OBJECTIVES AND JUSTIFICATION

The goal of the NASA program is to conduct aeronautical research and develop technology to strengthen U.S. leadership in civil and military aviation. The program is based on a strong commitment to develop a broad technology base in support of the aviation industry, enhance the safety and capacity of the national airspace system, and assure U.S. superiority for national security. The FY 1994 estimate reflects the need to address critical barriers and strengthen technology development in selected high payoff areas that are vital to our long-term leadership in aviation. NASA's aeronautics program is focused on six thrusts: (1) develop selected, high-leverage technologies and explore new means to ensure competitiveness of U.S. subsonic aircraft and to enhance the safety and productivity of the national aviation system; (2) resolve the critical environmental issues and establish the technology foundation for economical, high-speed air transportation; (3) ready technology options for revolutionary new capabilities in future high-performance fixed and rotary wing aircraft; (4) develop critical technologies and new methodologies for hypersonic-cruise and air-breathing space-launch vehicles; (5) pioneer the development of innovative concepts, and provide the physical understanding and the theoretical, experimental, and computational tools required for the efficient design and operation of advanced aerospace systems; and (6) develop, maintain and operate critical national facilities for aeronautical research and for support of industry, Department of Defense (DOD) and other NASA programs. In accomplishing these thrusts, the program will maintain NASA laboratory strength, including enhanced experimental and computational capabilities and staff excellence; ensure timely domestic technology transfer; ensure strong university involvement; and ensure strong support for and cooperation with the DOD, Federal Aviation Administration, and industry partners.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The aeronautics research and technology program reflects an overall decrease of $24.6 million. The research and technology base has been increased by a net of $42.5 million. A new discipline research program for hypersonic research has been established within the aeronautics research and technology base to consolidate total funding for these activities and give visibility to this program. The space research and technology portion of hypersonic funding ($5.1 million) has been reallocated to the aeronautics research and technology base to complete this consolidation. This increase to the research and technology base was offset by a reallocation of $2.1 million to Research Operations Support (ROS) for financial management system upgrades. An additional $39.5 million has been reallocated to the research and technology base as a result of the redistribution of ROS funding.

During FY 1993, a detailed Agencywide examination of activities supported by ROS funding was conducted to identify activities directly related to programmatic activities. Funding for activities dedicated to individual programs has been transferred to the benefiting programs. In total, the portion of ROS allocated to in the aeronautics program has been reduced by $94.4 million. This reflects the transfer of $82.3 million consistent with the restructuring activity and a reduction of $14.3 million consistent with Congressional direction. These reductions were offset by the reallocation of $2.2 million for financial management system upgrades at the Ames, Langley and Lewis Research Centers.

In the systems technology area, high-performance computing was reduced by $5.0 million consistent with Congressional direction. Some planned activities have been descoped or delayed to accommodate this decrease. Proposed FY 1993 supplemental legislation would provide an additional $4.7 million for this program. As directed by Congress, the rotorcraft systems technology program has been increased by $1.3 million, which will be used to fund detailed multidisciplinary analysis of a low noise rotor. As a result of Congressional action on the FY 1993 budget request, the high-speed research program been increased by $25.0 million, which will be used to augment NASA's ongoing program to initiate the highest priority areas in propulsion and airframe technology necessary for timely high-speed civil transport technology development. Also, a total of $6.0 million has been allocated to the systems technology programs as a result of the redistribution of ROS funding.

BASIS OF FY 1994 ESTIMATE

The FY 1994 research and technology program is committed to providing a broad foundation of advanced technology to strengthen the United States' leadership in aviation, an industry which plays a vital role in the economic strength, transportation infrastructure, and national defense of the United States. Today, we as a nation are being challenged by foreign competition, by an increasingly strained national airspace system, and by uncertainties about the future of the defense sector of the industry. Because of the importance of aeronautics to the country at this time, and the many ways in which NASA's unique research capabilities contribute to strengthening American aviation, the aeronautics program is being augmented as part of the NASA new technology investments in FY 1994 to pursue the high-leverage technologies required to support both the subsonic and high-speed civil transport economic viability. These augmentations are essential to the technology to ensure U.S. leadership for future competition of a high-speed civil transport and to address the important competitiveness and capacity issues associated with future subsonic transport aircraft. The demands for NASA's unique wind tunnels and other aeronautical facilities continues to increase with the growth of technology involved with civil and military aircraft development and modification programs. In order to support wind tunnel availability to meet these demands, continued emphasis will be placed on maintenance, instrumentation and revitalization of these unique national facilities. In FY 1994, the R&D augmentation for national facilities upgrade will be used for the development of design approaches and enabling technology for the highest priority needs for advanced facility capabilities.

In FY 1994, a number of programs are being realigned from systems technology into the research and technology base to consolidate activities of a similar nature. These include rotorcraft technology, advanced high-temperature engine materials technology, high-performance flight research, and general aviation/commuter core engine technology. Within systems technology, the ongoing noise reduction work which has been done under advanced propulsion systems technology is being realigned to the advanced subsonic technology program which it supports.

BASIS OF FY 1994 FUNDING REQUIREMENTS

RESEARCH AND TECHNOLOGY BASE

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Aerodynamics research and technology...	127,371	140,100	154,800	154,500
Propulsion and power research and technology.....	78,896	83,900	87,100	90,400
Materials and structures research and technology.....	38,068	40,600	35,100	48,500
Controls, guidance and human factors research and technology.....	49,329	73,500	66,400	59,400
Flight systems research and technology.	41,091	45,500	48,800	56,300
Systems analysis.....	8,542	10,400	11,650	10,200
Hypersonic research and technology.....	--	(25,600)	32,628	29,000
Total.....	343,297	394,000	436,478	448,300

OBJECTIVES AND STATUS

The overall objective of the research and technology base program is to provide a strong fundamental foundation for future aviation advances. Major emphasis is on fundamental understanding of a broad range of physical phenomena, development of computational methods to analyze and predict the physical phenomena, and appropriate experimental validation. These efforts ultimately lead to design and analysis tools with application to each of the six aeronautical strategic thrusts.

Aerodynamics research and technology addresses a broad spectrum of fluid flow problems from fundamental fluid physics to applied aerodynamics. These investigations include analytical and experimental efforts across the speed range for application to all classes of civil and military aircraft. The advanced computational methods developed by this research are used for more accurate and efficient prediction of aircraft aerodynamic performance, as well as for exploration of fluid physics phenomena. These fluid mechanics research efforts in FY 1993 are producing an improved understanding of flow transition mechanisms and turbulence dynamics, increased simulation and modeling capability, and provide the basis for new flow control concepts. Computational methods research also emphasizes the development and validation of advanced

analytical tools, including improved methods for configuration surface modeling and grid generation. Research in experimental techniques includes advanced sensor development for wind tunnel and flight testing. Nonintrusive global measurements were examined to reduce the time required to obtain surveys for data analysis and validation of computational methods. Luminescent paint for wind tunnel models is a revolutionary technique developed to provide real-time sensing of pressures over entire model surfaces. In the subsonic regime, flight and wind tunnel testing, as well as computational studies, were performed to improve aerodynamic efficiency and reduce noise. In FY 1993, the analysis of flight test results was continued on hybrid laminar flow control applied to a Boeing 757 aircraft to reduce drag. High-lift flap technology was advanced with analysis of flight data taken on the transportation systems research vehicle (TSRV). Vortical flow analyses and flight control methods were developed to provide improved handling qualities of high-performance aircraft at high angles-of-attack. Rotor research activities included initial flight airloads testing for acoustics and loads prediction. Advanced rotor and low noise airfoils were tested in the 40x80-foot wind tunnel.

The objective of the propulsion and power research and technology program is to explore and exploit advanced technology concepts for future aircraft propulsion systems in high-payoff areas through the focusing of fundamental research and technology efforts and integration of advanced propulsion components. The propulsion research and technology program has been devoted to increasing engine efficiency of next-generation large turbofans resulting in up to 30-percent reduction in fuel consumption. Preliminary studies indicate that these advanced turbofans will require very high operating pressure ratios (60:1 or greater), and temperatures (about 3000 degrees Fahrenheit) to achieve significant fuel reduction. Control of engine emissions at higher temperatures and pressures will be a key element of the propulsion technology development effort to reduce the adverse impact of subsonic aircraft engine emissions on the environment. In FY 1993, in-depth studies are being conducted in conjunction with industry to define critical propulsion technologies and engine configurations for the next-generation subsonic aircraft. The propulsion program will have addressed the selection of high-efficiency engine concepts using parametric analysis of various propulsion systems with varying bypass ratios and pressure ratios. The selection of the optimum configuration includes consideration of low-noise concepts, reduced emissions and the impact of engine airframe integration, while achieving high levels of engine performance. Disciplinary research in instrumentation, controls and internal fluid mechanics will be focused on propulsion technology areas including inlets for supermaneuvering vehicles, combustors and turbomachinery.

The materials and structures research and technology program is developing advanced materials, analysis methods, test methods and structural concepts to enable the design of safe, lightweight airframes and lightweight, durable, fuel-efficient engines. Materials and structures research is focused on understanding fundamental behavior, developing life prediction methodologies, and advancing fabrication technology for light metals, composites and high-temperature materials.

Computational structures technology is concerned with advanced analytical methods, from the micromechanics level through global response of full-scale aircraft, aeroelastic response and control, and multidisciplinary design and optimization. Under airframe materials research, work on processability and optimization of high-temperature resin RP46 is in progress. This material is a replacement for PMR-15 as a candidate material to be used in primary airframe structures. Laboratory research on high-temperature composites IM7/5260, IM7/8320, and IM7/K3-B is in progress to establish the relationship between physical aging and long-term creep and stress relaxation behavior. Optimized preparation of high-temperature polymer/graphite towpreg to be woven into fabric and evaluation of the composite properties are scheduled for FY 1993 completion. Fundamental mechanisms involved in oxidative degradation were experimentally investigated and efforts were initiated to develop analytical predictive models. Advances were made in chemical vapor deposition (CVD) methodology and predictive methods under the advanced fibers and fiber coating development effort. A computer code incorporating life prediction methodologies for high-temperature ceramics was completed. A benchmark test facility for biaxial high-temperature testing of generic engine components was designed and equipment is on order. Research efforts in aeroelasticity included benchmark models to measure unsteady aerodynamic pressures which were then used to validate aeroelastic computer codes. Computational structures technology (CST) continues to advance with demonstrated use of massively parallel computers in airframe and engine applications. More efficient ways of analyzing structures with defects, cutouts, etc. using the global/local approach were demonstrated.

The controls, guidance and human factors research and technology program supports applied research in the areas of flight crucial systems, airborne windshear detection, controls for highly agile aircraft, advanced cockpit and air traffic control integration with flight management systems, automated guidance and control for nap-of-the-Earth rotorcraft flight, and analysis of human performance in interaction with system automation. The program provides a technology base supporting future aircraft designs for safer and more efficient operations and greatly expanded flight envelopes and increasing National Airspace System capacity. A number of technology products will reach the state of maturity in which they are being validated in flight and in operational field tests in FY 1993. Operational tests of air traffic controller automation aids leading to increased system capacity were successfully undertaken in cooperation with the Federal Aviation Administration. Automated nap-of-the-Earth rotorcraft guidance concepts underwent flight evaluation in a cooperative effort with the Army. Flight crucial systems research on fly-by-light/power-by-wire applications will develop and test analytical and experimental methods for assessing electromagnetic effects on candidate system designs. The airborne windshear sensor program conducted flight evaluations of lidar (laser radar), infrared and Doppler microwave radar sensors to characterize performance in the presence of ground clutter and rain backscatter effects. Human factors research continued to focus on flight management, human engineering methods and cockpit automation aids. Flight evaluation of data link information transfer and in-flight planning/replanning aids was conducted using the TSRV. Full mission

simulation and empirical evaluation of electronic checklist designs, taxi way displays for low-visibility operations, and three-dimensional auditory cockpit displays for localization of traffic were completed. A design philosophy and guidelines for "human-centered" automation were developed and published.

Flight systems research and technology addresses a broad range of needs supporting aviation safety, flight test instrumentation and test techniques, and flight research for advanced technology demonstration/validation. The program objectives are accomplished by analysis, ground-based simulations, wind tunnel testing and flight research. Flight research is conducted using military high-performance aircraft to take advantage of their robust flight envelope, availability of production and experimental aircraft, and the available operational support. In aviation safety, a research program is being conducted to improve the fundamental understanding of aircraft operation during icing conditions. NASA's ice accretion prediction methodology, currently in wide use in the aviation industry, is being extended to the special problem of predicting glaze ice buildup. In short take-off and vertical landing (STOVL) technology, a small-scale hot gas ingestion vertical/short takeoff and landing (V/STOL) model has been constructed and is scheduled for test in the Lewis 9x15-foot low-speed wind tunnel. The high angle-of-attack research program is obtaining a flight-validated data base for design of highly agile aircraft. The high angle-of-attack research program continues to explore maneuverability and agility technology. Wind tunnel and flight-validated prediction methods are enabling aircraft designers to develop advanced concepts with high maneuverability and to design modifications for existing aircraft to enhance performance. Advanced computational fluid dynamics methods have been used to calculate the flowfield around the full F-18 high angle-of-attack research vehicle (HARV) configuration and within the inlet duct. Excellent correlation to data obtained from the F-18 HARV flights has been achieved for the external flow field. An inlet rake has been designed, fabricated and installed in the F-18 HARV for acquisition of data to validate the internal flow CFD code. The final design and fabrication for the F-18 HARV mechanical forebody vortex control device has been completed. Envelope expansion into the high angle-of-attack regime is continuing on the X-31 enhanced fighter maneuverability (EFM) aircraft in support of the Department of Defense. This vehicle is exploring post-stall maneuverability in the combat environment using lightweight external thrust vectoring vanes and an advanced multivariable flight control system. Initial SR-71 flight operations have been completed, providing an evaluation of operational costs and supportability in a flight research environment. An assessment of national requirements indicates the SR-71 will be useful in supporting high-speed and science research.

The aeronautics systems analysis program conducts long-term technology assessments, identifies technology applications, and performs sensitivity analyses and tradeoff studies from which effective research and technology programs can be developed to meet future civil and military aircraft requirements. Studies conducted under the systems analysis program focus on defining high-leverage, long-range research and technology needs for specific vehicle classes. In addition, the element includes work to develop advanced analytical techniques, and design and integration capabilities. Current efforts include conceptual design studies and environmental impact analyses for supersonic transport aircraft and propulsion systems. These

studies have shown that noise-reduction requirements will be a major consideration in airframe/engine integration for this class of aircraft. Also, supersonic laminar flow has shown the potential for greatly improved wing efficiency. Other studies are investigating technology tradeoffs for large subsonic transports, advanced rotorcraft, and high-performance aircraft to enable the most effective use of reaearch resources. Methods development work in FY 1993 includes enhancing multidisciplinary analysis with advanced geometry and data management methods, and linking it to an optimization module.

The hypersonic research and technology program utilizes NASA expertise and facilities in conjunction with university and industrial research to develop advanced, next-generation, high-risk/high-payoff, hypersonic technologies providing major innovative "leaps" in hypersonic vehicle performance which will ensure continued U.S. leadership in aeronautics. The program focuses fundamental research and technology development within the disciplines of ram/scramjet propulsion, aero/aerothermodynamics, materials, structures, guidance and control, technology integration, and the improvement of test techniques which will provide major advancements in future airbreathing, hypersonic launch vehicles, including single and two stage-to-orbit concepts. The program is currently conducting computer simulations to ascertain surface roughness effects on hypersonic laminar flow stability and will be completing development of a three-dimensional Navier-Stokes reacting flow code using multigrid, multiblock solvers. Advanced fuel injection and mixing concepts to increase scramjet supersonic combustion efficiencies are being studied. Room temperature testing of an advanced carbon-carbon control surface for a hypersonic vehicle is being completed. The program is evaluating the propulsion system sensitivity to aeroelastic deflections of slender, hypersonic vehicles. Rayleigh and laser-induced fluorescence techniques are obtaining planar "snapshots" of turbulent phenomena in high-speed mixing and combustion flows. Through joint efforts with industry, integrated multidisciplinary modeling and analysis tools are to be extended to include full computational fluid dynamics (CFD) implementation of multicycle combustion systems for complete vehicles. The program is broadening the effort in the development of university centers for training students and conducting research in hypersonic aeronautics with the intent of providing future experts in multiple hypersonic disciplines for U.S. industry, universities and the government. The current program has already produced 72 Masters and 57 Doctorate graduates in the fields of aerodynamics and aerothermodynamics.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The aeronautics research and technology base reflects a net increase of $42.5 million. A new discipline has been established within the aeronautics research and technology base for hypersonic research to consolidate total funding for these activities and give visibility to this program. The space research and technology portion of hypersonic funding ($5.1 million) has been reallocated to the aeronautics research and technology base to complete this consolidation. A total of $2.1 million has been reallocated from the aeronautics research and technology base to Research Operations Support (ROS) for financial management system upgrades, and $39.5 million has been reallocated to the research and technology base as a result of the redistribution of ROS funds.

The changes by the discipline program are as follows:

The aerodynamics research and technology program has been increased by $14.7 million. A total of $5.8 million of hypersonic funding has been reallocated to the newly established hyperaonic discipline, $0.4 million was transferred to ROS for financial management system upgrades, and $0.9 million has been realigned from the high performance area to support other high priority requirements.

Increases within this program include fundamental technology efforts applicable to subsonic technology ($2.0 million), high-speed technology ($1.3 million), computational aeroacoustics ($0.6 million), and wind tunnels and technical facilities ($3.7 million). In addition, $14.1 million has been allocated to this program as a result of the redistribution of ROS funds.

Propulsion and power research and technology was increased by $3.2 million. This includes the allocation of $11.4 million to the hypersonic discipline, $0.3 million transferred to ROS for financial management system upgrades, and a $1.3 million reduction in high-performance efforts. These reductions have been offset by increases of $2.0 million for rotary engine research, $1.7 million for high-pressure/temperature simulation, $1.0 million for supersonic cruise efforts, $0.9 million for wind tunnels and technical facilities, $0.2 million for computational aeroacoustics, and $10.4 million as a result of the redistribution of ROS funds.

The materials and structures research and technology program reflects a reduction of $5.5 million. This includes an allocation of $4.7 million to the hypersonic discipline and a realignment of $3.6 million to all speed regimes to support high priority subsonic activities in other research and technology base programs, which has been offset by the reallocation of $2.8 million from ROS.

The controls, guidance and human factors research and technology program has been decreased by $7.1 million. This is the net effect of a number of actions, including allocation of $1.7 million to the hypersonic discipline, a realignment of $1.4 million to ROS for financial management system upgrades at the research centers, and a general reduction of $6.5 million across all elements of the program to support other high priority research and technology base activities. Within this program, funding has been redirected to support transport system research vehicle upgrades ($2.0 million) and flight management efforts ($0.5 million). In addition, $2.5 million has been allocated to this program as a result of the redistribution of ROS funds.

Flight systems research and technology has been increased by $3.3 million. This includes a reduction of $3.1 million in the supersonic research to support other high priority research and technology base activities which has been offset by the transfer of $6.4 million from ROS. Within this program, $1.1 million has been realigned from the high-performance effort to support flight research activities and the optical air data system. The systems analysis program has been increased by $1.3 million as a result of the redistribution of ROS funds. In addition, $2.0 million was allocated to the hypersonic discipline, and this has been offset by an increase of $2.0 million to support subsonic systems analysis studies.

Hypersonic research and technology ($32.6 million) has been established as a separate discipline within the research and technology base to give visibility to these activities. This represents a consolidation of hypersonic funding previously in other aeronautics research and technology base disciplines ($25.6 million), the hypersonic funding previously funded in the space research and technology base ($5.1 million), and a transfer of $1.9 million resulting from the redistribution of ROS funds.

BASIS OF FY 1994 ESTIMATE

Aerodynamics research and technology will continue to address a broad spectrum of fluid flow problems from fundamental fluid physics to applied aerodynamics in FY 1994. Computational methods will be applied on computers with advanced architectures and include improved methods for representing the surface of aerodynamic configurations being modeled, improved techniques for rendering the locations being considered, as well as advanced modeling of the algorithms used to solve the fluid flow equations. In addition, a multidisciplined approach will be undertaken to expand the scope of computational fluid dynamics to properly account for propulsion, chemical processes, structural effects and flight control laws. Experimental research will be expanded to include techniques such as the use of heavy gas in wind tunnels to provide Reynolds numbers higher than available from air, but closer to aircraft flight Reynolds numbers. A closer association between computational fluid dynamics and advanced techniques will result in nonintrusive global measurement techniques to reduce the time required for accurate flow field surveys and computational methods validation. In 1994, a joint NASA and industry program will be initiated to resolve discrepancies that were encountered in the laminar flow flight testing of the Boeing 757 aircraft. A wind tunnel model will be designed and fabricated for joint testing in a NASA or Boeing facility in 1995. The results from current wind tunnel and flight tests on the TSRV aircraft will be used to validate two-dimensional computational programs on high-lift devices. Rotorcraft aeroacoustics and high-speed rotorcraft were moved from systems technology to the aerodynamics research and technology base program. Two major activities from that area will be completed under the rotorcraft base program in the FY 1994 time frame. First, a major inspection, and subsequent rehabilitation of the XV-15 tiltrotor aircraft will be complete prior to undertaking an acoustic and terminal area flight investigation in FY 1995. To support that activity, tests will be undertaken on the vertical flight simulator in order to define the test matrix for the flight tests that are scheduled for FY 1995. In FY 1994, the national facility augmentation will be used to develop design approaches and enabling technology for the highest priority advanced facility needs.

In FY 1994, propulsion and power research and technology will focus on high-pressure ratio compressors, high-temperature and low-emission combustors and high-temperature turbines. The propulsion technology will continue to define the details of subscale component technologies for both the cold and hot end sections of the propulsion system with an emphasis in the high-pressure turbine, and low-emission combustor components. The program effort will be focused on development of the technologies for the specific engine concepts and configurations that are consistent with the industry's vision of the next-generation high-bypass-ratio turbofans.

The general aviation/commuter engine technology effort which has been realigned from systems technology will continue to demonstrate component improvements through the practical application of validated analysis codes that will enable high-performance small engine systems. Experimental data acquired from combustor ceramic liner tests and using three-dimensional Navier-Stokes two-phase reacting flow code will provide the required design input for demonstration of an advanced combustor with a very aggressive pattern factor of 0.1 at a combustor exit temperature of 2800 degrees Fahrenheit. Novel fuel injection concepts will be developed for small combustors. A combinstion of these new concepts and high-temperature combustors for high-pressure ratio, small core engines will lead to reduced fuel consumption. For turbomschinery, axial flow compressor experimental data will be used for validation of multistage average passage code to design and predict axial compressor performance.

The materials and structures research and technology efforts will continue to focus on developing advanced materials and innovative structural concepts which can reduce aircraft weight and cost, enhance performance and durability, and improve aircraft safety. Improved understanding of the impact of material processing parameters on material performance under complex loading conditions will be used to tailor overall material development activities including intelligent processing. Materials research activities will include development of high-temperature organic composites for use up to 800 degrees Fahrenheit, and high-temperature aluminum alloys for design applications up to 450 degrees Fahrenheit. Processing scale-up of the high-temperature resin RP46 will be completed and this material will be made available for commercial use. Research in advanced materials will include micro- and macromechanical modeling of high-temperature, time-dependent behavior such as creep and fatigue. Creep and toughness properties and failure mechanisms of General Electric's nickel aluminide alloys for turbine blades will be examined to guide General Electric's development effort. Failure modes/mechanisms from long-term aging of graphite/PMR-15 composites will be identified and engine component specific analytical models to predict service life at temperatures from 400 degrees Fahrenheit to 650 degrees Fahrenheit will be developed. During FY 1994, structures research will include a focus on developing improved coupled thermal/aerodynamic/structural analysis and accelerated test methods for aircraft structures and propulsion systems. Unsteady aerodynamics research will be directed toward expanding aeroelastic and flutter analysis capability for complete airframe structures, using advanced three-dimensional analytical methods with improved accuracy and lower cost, and benchmark wind tunnel tests to verify analytical predictions. Also planned is the development of multidisciplinary coupled finite element and computational fluid dynamics capability for transonic aeroelasticity. These areas will be supported by real-time flight aeroelastic data analysis capability. Research in structural mechanics will include evaluation of the effects of tailored stiffness and thickness distributions on the behavior of composite plates and shells. Efforts in the propulsion structures area will provide computational simulation of a complete engine accounting for coupled aerodynamic and structural effects. A working version of the engine structures computational simulator (ESCS computer code) will be delivered.

The advanced high-temperature engine materials program (HITEMP), which has been realigned from systems technology, will continue to focus on development of lightweight, high-temperature polymer matrix composites (PMC's) for fan and compressor applications up to 800 degrees Fahrenheit; intermetallic matrix composites

and metal matrix composites (IMC's and MMC's) for compressor and turbine applications up to 2300 degrees Fahrenheit; and ceramic matrix composites (CMC's) for turbine applications up to 2500 degreea Fahrenheit. A new fiber sizing for 700- to 800-degrees-Fahrenheit use and polymer coatings which are resistant to oxidation up to 800 degrees Fahrenheit will be developed. A fiber/matrix interface model designed to help overcome the incompatibilities between current ceramic fibers and intermetallic matrix materials will be verified and a new, more compatible ceramic fiber will be demonstrated. IMC efforts will also emphasize development of oxidation-resistant coatings, thermal barrier coatings and joining techniques. Oxidation-resistant fiber coatings for CMC's will be demonstrated, and processing methods will be optimized and transferred to industry. The performance, economic and environmental benefits of PMC's, IMC's and CMC's will continue to be verified in core and engine tests through ongoing cooperative efforts with the major U.S. gas turbine manufacturers.

In the controls, guidance and human factors research and technology program, the area of flight crucial systems will continue to place emphasis on the development and validation of design and assessment tools which support cost-effective certification of highly reliable electro-optical flight systems and on methods for automated development of reliable software. Emphasis will be placed on the application of analytical and experimental tools developed for assessing electromagnetic effects on electro-optical flight systems. The successful completion of windshear sensor and integration tests in FY 1993 leads to application of windshear alerting technologies for other aviation hazards, and insertion of those technologies in flight deck and National Airspace System integration efforts in FY 1994. Evaluations of automated aids for air traffic controllers were undertaken in the Denver terminal area. In FY 1994, the final approach spacing tool will be installed at Dallas-Fort Worth for evaluation. Simulation and flight evaluation of cockpit automation aids will be conducted, and increased emphasis will be placed on investigating the integration of aircraft equipped with advanced technologies, such as synthetic vision, data link and global positioning system (GPS), into the National Airspace System. In the area of enhanced agility for highly maneuverable aircraft, new control laws for mechanical control of vortices are being flight-tested in the HARV. Evaluation of helmet-mounted display for highly maneuverable aircraft will be undertaken in ground-based simulation in FY 1994 preparatory to 1995 flight tests. Flight evaluation of vision-based passive ranging algorithms, required for rotorcraft nap-of-the-Earth flight guidance, will be completed in FY 1993. Installation of a precision GPS-based navigation system, helmet-mounted display system, and a guidance computer in the UH-60 RASCAL helicopter will be completed in FY 1994. Generic research in controls is aimed at developing error-tolerant flight system technology through advanced active control theory, integrated engine airframe controls and artificial intelligence-based controls. Fundamental research in human factors will continue to develop scientific principles and "human-centered" technologies to improve design efficiency and operational safety of advanced flight systems by providing methods to reduce the operational impact of human errors. Efforts in FY 1994 will focus on integrated "human-centered" advanced subsonic aircraft cockpit development and test, and on identification of human capabilities and limitations in the flight deck and National Airspace System integration for increased terminal area productivity. Research and field evaluations of fatigue countermeasures for air crews, such as evaluation of in-flight bunk-sleep facilities, will continue. The current technology glass cockpit simulator is being installed in FY 1993 and ready for research in FY 1994.

In flight systems research and technology, experiments will be conducted to validate the ability of prediction methodologies to accurately describe the shape of the three-dimensional ice build-up on airplane wing and tail surfaces. A joint NASA/Sikorsky test of a subscale helicopter rotor model to acquire further data on rotor blade performance in icing conditions will be completed in NASA's Icing Research Tunnel. The portion of the high angle-of-attack research program element in the high-performance aircraft systems technology program has been consolidated herein and the program will concentrate on technology validation experiments. These experiments are focused on flight validation of the most promising new technologies, including advanced controls for thrust vectoring, mechanical forebody vortex controls, and wide-angle helmet-mounted displays. Advanced thrust vectoring control laws designed for agility will continue to be flight tested during FY 1994. Installation and checkout of the mechanical forebody vortex controls will occur and flight research will begin. Military utility evaluation of the X-31 will be completed. The Defense Advanced Research Projects Agency (DARPA) has initiated the STOVL strike fighter technology demonstrator program; consequently, the objectives of NASA's STOVL research and technology have been reassessed. The STOVL program now aims to support DARPA with NASA's unique technology expertise and facilities to ensure success of the DARPA STOVL strike fighter program. Integration of the integrated flight/propulsion control software and servos on the V/STOL research aircraft, YAV-8B Harrier, will be completed and the initial flight experiments begun (transferred from systems technology). These experiments investigate guidance/display schemes and integrated flight and propulsion concepts for the hover and transition flight regimes. Continued support for the design, fabrication, installation, definition and conduct of experiments benefiting a high-speed civil transport (HSCT) provide the major focus for the SR-71 flight research testbed for FY 1994. The advanced propulsion/flight controls integration research is being transferred from systems technology. This activity will use the F-15 STOL and maneuver technology demonstrator and will incorporate axisymmetric vectoring engine nozzles. The aircraft engines will be fitted with the new nozzles, and flight research will be initiated to improve aircraft performance and safety.

In FY 1994, the aeronautics systems analysis program will continue the development of analytical and multidisciplinary design methods. Conceptual design methodology will be expanded to include cost as a primary optimization function and incorporate analytical models for weight and cost on a component basis. The resulting methodology will be implemented on a parallel computing system in order to provide adequate computing power for the increased complexity and detail currently envisioned. Supersonic transport studies will continue with an investigation of propulsion/airframe integration concepts. A detailed evaluation of the supersonic throughflow fan propulsion system will be completed. Alternative concepts for an HSCT, emphasizing configurations that are optimized for supersonic laminar flow, will be explored. The preliminary design of an efficient propulsion system with low noise and emissions for an advanced subsonic transport will be completed. High-performance aircraft studies will analyze the benefits and technological costs of increasing agility according to refined agility metrics.

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Hypersonic research and technology will continue to concentrate on the development of innovative, high-risk/high-payoff technologies which will provide the foundation for future competitive aeronautical systems. Hypersonic aerodynamics researchers will investigate fundamental hypersonic flow mechanisms with emphasis on predicting transition location and turbulence development, methods for effective airframe/propulsion integration on advanced hypersonic vehicles, and gas aerothermodynamics phenomena. Hypersonic propulsion activities will be focused on the completion of semidirect connect tests of an advanced ramjet/scramjet engine design for verification of thermal choking and stable ramjet-to-scramjet transition (Mach 3.5 to 5) using nonintrusive laser diagnostics. Continued investigation of lightweight, high-temperature structural materials with applicability to hypersonic vehicles, other aeronautical systems and other industries will include increased emphasis on carbon-carbon materials and structures technology for both airfoil leading edges and scramjet engine panels, development of novel methods for processing graphite/copper metal matrix composites, and advancement of fundamental understanding of hydrogen degradation mechanisms in a variety of promising lightweight, high-temperature alloys. Analyses of the aeroelastic deflections of slender vehicle forebodies and the resulting propulsion transients will be continued to resolve the controllability issues associated with hypersonic flight dynamics. Through joint efforts with industry, integrated multidisciplinary modeling and analysis tools will be advanced by coupling massively parallel processing techniques with multiparameter optimization methods, which will then be applied to real airplane data. The development of advanced sensors and measurement systems for operation in the severe hypersonic environment will continue with further development of high-temperature sapphire fibers and optical test techniques to 2500 degrees Fahrenheit. The impact of boundary-layer crossflow transition on the performance of airbreathing hypersonic vehicles will be obtained in flight using a specially designed glove on the PEGASUS space launch booster wing. This "piggy-back" flight experiment on a scheduled PEGASUS satellite provides the opportunity to obtain real flight data at a minimum cost. In addition, three universities will be in their second year of participation in the continuing hypersonic training and research program.

BASIS OF FY 1994 FUNDING REQUIREMENTS

SYSTEMS TECHNOLOGY PROGRAMS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
	(Thousands of Dollars)			
High-performance computing.....	16,980	35,000	30,359	65,600
Materials and structures systems technology.....	37,562	35,500	36,628	*25,700
Rotorcraft systems technology.....	4,900	5,400	6,977	*
High-performance aircraft systems technology.....	10,700	11,900	12,070	*
Advanced propulsion systems technology.	15,180	16,000	16,900	*
Numerical aerodynamic simulation.....	45,400	47,000	47,930	49,100
High-speed research.....	76,400	89,900	116,995	187,200
Advanced subsonic technology.....	5,000	12,300	12,425	*101,300
Total.....	212,122	253,000	280,284	428,900

* Materials and structures systems technology: Advanced high-temperature engine materials ($10,523) transferred into the materials and structures portion of the research and technology base.

* Rotorcraft systems technology: Advanced rotorcraft ($5,280) transferred into aerodynamics portion of the research and technology base.

* High-performance aircraft systems technology: High-performance flight research ($9,570) transferred into the flight systems portion of the research and technology base.

* Advanced propulsion systems technology: General aviation/commuter engine technology ($3,085) transferred into the materials and structures portion of the research and technology base and advanced turboprop systems ($15,246) transferred into advanced subsonic technology.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
High-performance computing.....	16,980	35,000	30,359	65,600

OBJECTIVES AND STATUS

The High-Performance Computing and Communications (HPCC) program is a multi-agency endeavor which involves NASA, the Department of Energy, the National Science Foundation, the Department of Defense (DOD), the Department of Commerce, the National Institutes of Health, and the Environmental Protection Agency.

The goal of NASA's portion of the HPCC program is to accelerate the development and application of high-performance computing technologies to solve the Agency's Grand Challenge research problems. Grand Challenges are fundamental problems whose solutions require significant increases in computational power and are critical to meeting national needs. The NASA HPCC program is focused to enable broad advances in aerospace vehicle design and Earth and space systems science research.

NASA's primary role in the federal program is leading the development of applications software and algorithms suitable for massively parallel computing systems which will increase system performance to the sustained teraFLOPS (10^{12} floating point operations per second) level. Its other roles include evaluating experimental hardware for testbeds, supporting the development of the National Research and Education Network (NREN), promoting long-term research of the underlying theory and concepts of high performance-computing and increasing the pool of personnel trained to use HPCC technology.

NASA is the lead agency for coordinating plans to develop systems software and tools for the federal HPCC program. In April 1993, a workshop of experts from industry, academia and government will be convened to produce a national agenda for software and tools for high-performance computing applications. A technical report will summarize their findings, and this report will be used to help formulate a national perspective on systems software requirements. NASA also is leading federal efforts to make HPCC software less expensive and more robust by encouraging software sharing and reuse. In FY 1993, NASA has established an experimental software exchange system that connects software repositories across a number of federal agencies. A series of metrics has been developed to compare alternate architectures for future generations of the exchange system.

During FY 1993, significant progress has been made in the program including: awarding grants to multidisciplinary research teams to support the Earth and Space Sciences (ESS) project, and contributing to, and continuing to act as a member of the Concurrent Supercomputing Consortium for the use of Intel

Corporation's massively parallel Delta Touchstone supercomputer installed at the California Institute of Technology. Specific accomplishments include: generating 3-dimensional images of the planet Venus from Magellan satellite data; direct numerical simulation of large, time-dependent compressible Navier-Stokes equations; and 3-dimensional compressible turbulence simulations for high Reynolds numbers.

Single discipline computational fluid dynamics (CFD) codes were adapted for a number of massively parallel supercomputers including the Thinking Machines CM2 and Intel iPSC/860. These pilot fluid codes are being applied to both high-speed civil transport and high-performance aircraft applications. NASA also accomplished the benchmarking of multidisciplinary codes on parallel supercomputers, including the development and demonstration of a coupled aerodynamics and structures code on the Intel iPSC/860 supercomputer. Furthermore, NASA researchers have created methods for streamlining the process required for developing an optimal airframe design. The development of these codes complements the High-Speed Civil Transport (HSCT) program by allowing aircraft manufacturers to analyze different design options rapidly and produce vehicles more efficiently with optimal performance and reduced design cycle costs.

NASA researchers also have established a parallel computing testbed using a cluster of high-end IBM workstations. This testbed will provide for the early evaluation of clustered workstations for multidisciplinary aeropropulsion simulation.

NASA also contributed to the advancement of the National Research and Education Network by entering into a cooperative agreement with the Department of Energy to procure research network services based on emerging cell-switching technology that operates at 45 megabits per second (mbps). This is a vast increase over previous network services which only operate at 1.5 mbps. These interconnects are essential to connect NASA field centers at greater data exchange rates and provide industrial and university researchers access to NASA computing testbeds.

In addition, NASA made several contributions to the program's Basic Research and Human Resources component by funding in-house activities to develop advanced algorithms for multidisciplinary applications on parallel computing testbeds. It provided funding support for university efforts through NASA research institutes and provided funding for seven graduate student researchers. Finally, NASA advanced its outreach efforts for K-12 grade students by selecting two pilot high schools to begin the development of networking-supported research and education activities.

CHANGES FROM FY 1993 BUDGET ESTIMATE

This program was reduced by $5.0 million as a result of Congressional action on the FY 1993 budget request. This decrease has been accommodated in both the computational aerosciences and in the Earth and space sciences area. Some planned activities will be delayed or descoped to accommodate this reduction. This decrease was offset by the addition of $0.4 million resulting from the restructuring of Research Operations Support (ROS). The estimate does not reflect the approximately $4.7 million in additional funding requested in FY 1993 as part of President Clinton's economic stimulus package.

BASIS OF FY 1994 ESTIMATE

In FY 1994, NASA's HPCC program is focused on two areas of application: integrated, multidisciplinary computational aerospace vehicle design and multidisciplinary modeling and analysis of Earth and space science phenomena.

NASA plans to initiate activities to broaden the reach of the HPCC program and begin the development of a national information infrastructure by supporting research and development in education, digital library technology, manufacturing and design, and access to Earth and space science data. In education, NASA will increase its focus on developing K-12 education products available over the NREN and establishing teacher training programs for the utilization of NASA education products. In manufacturing and design, it will expand cooperative efforts with industry and academia for multidisciplinary design of aeronautical airframes and engines, and increase its reach to include other industrial sectors such as electronics and automotive. In digital library technology, NASA will advanced technology in petabytes data storage systems, full test retrieval, multimedia standards, classification guides and catalogues for scientific and technical information and visualization. NASA also will increase efforts to make Earth and space science data more widely available by developing and evaluating prototype digital data bases of images and software that are available over the NREN.

Grand Challenge software applications research will proceed in two distinct projects: the computational aerosciences (CAS) project and the Earth and space sciences (ESS) project. The CAS project will direct its efforts towards continuing the development of multidisciplinary algorithms and advanced software technology in two Grand Challenge areas. These areas are high speed civil transport (HSCT) and high-performance aircraft applications. The ESS project will focus on Grand Challenge teams selected in FY 1993 in the areas of: climate modeling; studying ocean, land and atmosphere dynamics; modeling magnetosphere-solar wind interactions, stellar interiors and surfaces, star/galaxy creation and evolution, and the formation of other cosmological structures; analyzing enormous geophysical databases; and the assimilation of atmospheric data.

Testbeds are a crucial part of this program because they provide a key tool for interdisciplinary research teams to develop and evaluate applications and systems software and to evaluate scalable hardware architectures and peripherals. A key to successful exploitation of massively parallel computing power will be the blending of application-driven and architecture-driven computer systems and software to most effectively meet NASA's needs. Second generation prototype testbeds of up to 20 gigaFLOPS are scheduled to become operational in FY 1994, with third generation testbeds of 50 to 200 gigaFLOPS set to become operational in FY 1996. These testbeds will not be replacements for the numerical aerodynamic simulation (NAS) system or any of NASA's other computational facilities, but rather will serve as proof-of-concept systems which could be used by those computing facilities once the systems are scaled up and ready for operational use.

NASA's needs for systems software in the FY 1994 timeframe and beyond are being framed by the NASA-led team in charge of coordinating federal systems software. To date, some of the needs that have been identified include: operating systems, compilers, programming environments and visualization software. Other important requirements include dynamic load balancing of processors in parallel and distributed systems and the development of operating systems which permit heterogeneous computing. Still other significant areas include programming languages and environments because they are the mechanisms which developers use to interface to high-performance computing systems.

Agency plans under the Basic Research and Human Resources Element include approximately doubling the number of graduate student researchers in the program. NASA plans also include identifying NASA-owned or controlled assets to deploy on the NREN for education, conducting workshops to develop K-12 assets and curricula and integrating its efforts with those of other federal agencies.

Finally, NASA's testbed systems must be hooked up to a nationwide research network to allow access by supporters of the federal HPCC program. Only in this fashion can applications developers have access to the broad range of architectures they require. NASA is meeting this requirement through its participation in the NREN. Agency NREN plans call for establishing 155 Mbps connections among NASA HPCC testbed sites in FY 1994 and upgrading that capability to 633 Mbps by FY 1996.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Materials and structures systems technology.....	37,562	35,500	36,628	25,700*

* Advanced high-temperature engine materials ($10,523) transferred into the materials and structures portions of the research and technology base in FY 1994.

OBJECTIVES AND STATUS

The objective of the materials and structures systems technology program is to develop advanced materials and structural concepts for future advanced aircraft propulsion systems and primary structures. The program is conducted in two tasks, one focused on advanced high-temperature engine materials technology and the other focused on advanced composites technology for airframe structures.

The advanced high-temperature engine materials technology program is a focused laboratory-scale materials and structures research program with application to the complete range of aircraft propulsion systems, including rotorcraft, subsonic and supersonic transports. Major consideration is given to propulsion systems that will be friendly to the environment in terms of minimizing pollution and noise, and that will be economical via reducing fuel consumption and direct operating costs while extending life and improving reliability. These goals require very high thrust-to-weight (20 to 1) gas turbine engines with durable, long-life, high-temperature components. Key to these applications are ceramic matrix composites (CMC's), metal matrix composites (MMC's), intermetallic matrix composites (IMC's), and polymer matrix composites (PMC's) which can endure sustained operation at elevated temperatures. Advanced analysis, design and life prediction methods are being developed for these materials to provide an understanding of composite architecture, processing, fiber/matrix interaction, and failure mechanisms at temperatures up to 3000 degrees Fahrenheit. Supporting technologies are also being developed in the areas of high-temperature instrumentation, nondestructive evaluation (NDE), and aerodynamic/thermodynamic loads definition. During FY 1993, the advanced high-temperature engine materials element is continuing the development and characterization of high-temperature PMC's, IMC's, and CMC's. High molecular weight polymers are being evaluated for high-temperature PMC's. IMC efforts continue to focus on development and demonstration of fibers and fiber coatings, optimization and demonstration of composite fabrication processes, and development and verification of analytical and NDE methods. CMC efforts are concentrating on: development of small-diameter ceramic fibers/coatings that are stronger and more creep resistant than current fibers; continued investigations into the environmental and microstructural factors limiting CMC use temperature and life; development and verification of analytical methods for predicting the reliability of CMC structures;

and the development and demonstration of high-temperature test methods and NDE methods. Technology transfer will continue to be addressed through cooperative efforts with the major U.S. turbine engine manufacturers. A fiber sizing that will withstand use temperatures of 700 to 800 degrees Fahrenheit will be verified through an engine core test of a high-temperature PMC actuation ring. Oxidation-resistant coatings for CMC's will undergo engine testing in a turbine shroud application.

The objective of the advanced composite materials systems technology program is to develop innovative cost-effective structural concepts and fabrication processes to more fully exploit the advantages of composite materials in primary structures of future aircraft. While the current demonstrated level of composites technology can promise improved aircraft performance through reduced structural weight, it does so at an inhibiting increased cost. Further development of the technology is pursued through material formulation and processing refinements, innovative fabrication concepts with their resulting unique structural configurations, and analytical developments for improved structural behavior prediction. The improved technology levels will be demonstrated and validated by fabrication and testing at the subcomponent and subscale component levels. Such validation is an essential building block leading to full-scale primary structures. The program goals are to develop technology that will reduce airframe structure acquisition costs by 25 percent and structural weight by 30 to 50 percent, after resizing the aircraft for maximum benefit. To achieve these goals, a new approach to composite design must be developed by integrating the design concepts with advanced fabrication techniques using new material forms. Understanding of failure mechanisms and behavior under complex loadings is critical to establishing the data base for innovative design with composites. The new structural concepts, (advanced fiber placement, woven textile preforms, and resin transfer molding), continue to show potential for achieving cost-effective composite primary aircraft structures. A fuselage crown panel fabricated by advanced fiber placement has been successfully demonstrated. Compared to equivalent metal crown panel structures, the composite panel design is estimated to be 30-percent lighter and 20-percent less expensive to build. Tests will measure the structural performance of this design under selected loading conditions in the presence of various types of damage. One panel will be damaged and then repaired by a major airline prior to structural testing. Woven preforms based on technology borrowed from the textile industry show promise for major subcomponents of fuselage panels including frames, window belts, and keel beam/frame intersections. The two- and three-dimensional braiding techniques applied to window belts showed the most potential for cost savings while maximizing the strength advantages offered by composites. Progress continues in the development of a new stitching machine. Two 4x5-foot stiffened wing panels, which were fabricated using stitched preforms and the resin transfer molding process, were successfully tested under compression loading with induced damage. Good progress is being made in analytical methods development to support the design of composite wings and fuselages. The third technical conference, held to disseminate results to airframe manufacturers and materials suppliers, was well attended and the fourth conference is scheduled for June 1993.

CHANGES FROM FY 1993 BUDGET ESTIMATE

This program reflects a net increase of $1.1 million as a result of the redistribution of ROS funds.

BASIS OF FY 1994 ESTIMATE

In FY 1994, the advanced high-temperature engine materials technology program has been transferred into the materials and structures portion of the research and technology base.

During FY 1994, in the advanced composites technology program, development of design and manufacturing techniques for composite fuselage subcomponents and full-scale wing components will continue with a significant emphasis on verification testing. Validation of the fuselage keel damage tolerance and load redistribution will be completed. Testing of the woven textile frames and window belts and development of innovative tooling and requirements for a weaving machine will be completed. Testing will continue on the fuselage side panels to ensure the pressure load is properly distributed about the windows. Testing will begin to assess the load transfer across the major intersection between the fuselage crown and side panels. Completion of benchmark tests for fuselage panels to verify the analytical methods will allow prediction of the behavior of a full-scale fuselage. A cost model developed under this effort will be exercised to predict the cost and weight of the fuselage. Major milestones in the development of the composite wing will also be reached during FY 1994. These milestones include wing subcomponents design, fabrication and testing; tooling design, fabrication and checkout; and the design of a full-scale semispan composite wing box. Completion of development of RTM/stitching technologies in FY 1994 will enable initiation of fabrication of the wing box. The experimental characterization of the mechanical properties, damage tolerance and fatigue response of RTM-type resins and laminate architectures of woven and stitched preforms will be completed. The advanced stitching equipment will be constructed. The fifth technical conference will be held to ensure continued dissemination of the technology to airframe manufacturers and materials suppliers.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Rotorcraft systems technology.....	4,900	5,400	6,977	

- Advanced rotorcraft ($5.280) transferred into the aerodynamics portion of the research and technology base in FY 1994.

OBJECTIVES AND STATUS

The rotorcraft systems technology program is focused on developing technologies for rotorcraft noise reduction and for tiltrotor aircraft.

Noise reduction was identified by NASA as the highest priority research area in tiltrotor aircraft. Simulations of steep approaches for noise abatement are being made to define the envelope to be evaluated in flight tests with the XV-15. The design and fabrication of the tiltrotor aeroacoustic model (TRAM), started in 1992, is being continued. That model is to be used for detailed airloads and acoustic testing in low-noise wind tunnels when complete in 1994.

Several promising innovative concepts for noise reduction are being evaluated in numerical studies. The compromises presented by each, in terms of complexity, performance, and noise reduction, are being evaluated to determine which concepts will be carried forward to small-scale wind tunnel tests. The results of those tests, also scheduled for 1994, and computational analysis will determine which concepts will be carried to full-scale evaluation.

CHANGES FROM FY 1993 BUDGET ESTIMATE

This program was increased by a total of $1.6 million, including $1.3 million for civil tiltrotor technology as a result of Congressional action on the FY 1993 budget request and $0.3 million resulting from the redistribution of ROS funds.

BASIS OF FY 1994 ESTIMATE

Rotorcraft aeroacoustics and high-speed rotorcraft are being moved from systems technology to the aerodynamics portion of the research and technology base.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
High-performance aircraft systems technology.....	10,700	11,900	12,070	

* High-performance flight research ($9,570) transferred into the flight systems portion of the research and technology base in FY 1994.

OBJECTIVES AND STATUS

This program generates validated methods and design data applicable to the development of advanced high-performance aircraft applications. The program objectives are accomplished by analysis, ground-based simulations, wind tunnel testing, and flight research involving tests of advanced aircraft concepts and systems. The high angle-of-attack research program is obtaining a flight-validated data base for design of highly agile aircraft. The F-18 high angle-of-attack research vehicle (HARV), equipped with the thrust vectoring control system (TVCS), completed envelope expansion. The flight evaluation of the baseline TVCS control laws has been completed and the first set of advanced control laws has been installed and is in the process of flight evaluation. The F-15, with highly integrated digital electronics controls, continues to demonstrate the capability to actively determine and adjust critical engine and flight control parameters with real-time parameter estimation methods. Substantial improvement to the specific fuel consumption and aircraft performance at both subsonic and supersonic speeds has been demonstrated. The program has also demonstrated a very significant increase in the engine life throughout the full flight envelope by reducing engine temperatures while maintaining thrust. The vertical/short takeoff and landing (V/STOL) research aircraft YAV-8B Harrier flight research program investigates guidance/display schemes, and integrated flight and propulsion concepts for the hover and transition flight regimes. The modification to the propulsion control system of the V/STOL research aircraft is nearly completed, providing a highly versatile, digitally implemented longitudinal and propulsion control system to properly support the continuing investigations critical to all future V/STOL designs. Initial system integrity flights will be accomplished in FY 1993. Two F-16XL testbed aircraft are on loan from the Air Force to support high-speed research. One aircraft has completed an initial laminar flow experiment that established the feasibility of achieving laminar flow at supersonic speed. The second aircraft has been used to gather fundamental information neceasary to design a more definitive supersonic laminar flow experiment dedicated to the systematic investigation of supersonic laminar flow control devices including a passive leading-edge glove to obtain attachment line criteria, surface pressure and transition data for code calibration, and transition prediction technique improvements.

CHANGES FROM FY 1993 BUDGET ESTIMATE

This program was increased by $0.2 million as a result of the redistribution of ROS funds.

BASIS OF FY 1994 ESTIMATE

The high-performance aircraft systems technology activities are being transferred to the flight systems portion of the research and technology base.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Advanced propulsion systems technology.....	15,180	16,000	16,900	

- General aviation/commuter engine technology ($3,085) transferred into the materials and structures portion of the research and technology base, and advanced turboprop systems ($15,246) transferred into advanced subsonic technology in FY 1994.

OBJECTIVES AND STATUS

The objective of the advanced propulsion systems technology program is to explore and exploit advanced technology concepts for future aircraft propulsion systems in high-payoff areas through the focusing of fundamental research and technology efforts and integration of advanced propulsion components.

The advanced turboprop systems program is directed toward establishing low-noise, high-bypass concepts and providing the broad research and technology data base necessary for achieving maximum source noise reduction for subsonic propulsion systems. In FY 1993, the advanced turboprop program is focused on the noise reduction of high-bypass ratio engines. The program will select an optimum low-noise concept and cycle which includes consideration of engine airframe integration while maintaining high levels of engine performance. Preliminary testing of the advanced fan and nacelle concepts will be initiated. The engine source noise reduction will positively impact the U.S. aircraft industry's competitiveness in the global market as international noise standards become more stringent in the future.

In the general aviation/commuter engine technology program, the objectives are to raise the performance level of small turbine engines to approximately that of large transport turbine engines, with a decrease in fuel consumption. Propulsion efficiency research will be focused on developing an understanding of governing flow phenomena in small-size turbomachines at the component level. The work will be focused on providing a detailed understanding of the design parameters that affect component performance through the development of analytical codes and the associated experimental data base for validation. In FY 1993, the research emphasis will shift from radial inflow turbine concepts toward axial compressor technology. The performance testing of a multistage axial compressor with realistic tip clearances will be initiated. In-depth experimental evaluation of axial compressors will provide an understanding of mixing phenomena, which control the performance of multistage compressors, used in small turboshaft engines and large turbofans.

CHANGES FROM FY 1993 BUDGET ESTIMATE

This program was increased by $0.9 million as a result of the redistribution of ROS funds.

BASIS OF FY 1994 ESTIMATE

In FY 1994, the advanced turboprop systems program will be transferred to advanced subsonic technology as the noise reduction element to more appropriately reflect the nature of the work. The general aviation/commuter engine technology effort will be transferred into the materials and structures portion of the research and technology base.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Numerical aerodynamic simulation.....	45,400	47,000	47,930	49,100

OBJECTIVES AND STATUS

The numerical aerodynamic simulation (NAS) program objective is to significantly augment the Nation's capabilities in computational fluid dynamics (CFD) and other areas of fluid physics by developing a preeminent capability for the numerical simulation of aerodynamic flows. The NAS system continues its national operation by closely associating with and providing resources to other NASA programs, the Department of Defense (DOD), other Government agencies, industry and academia. This program provides the computing power which may not be available from other NASA computing facilities. The NAS facility provides the tools and resources dedicated to obtaining solutions to problems which may be intractable on less than state-of-the-art computer systems, including solutions to the Navier-Stokes equations (enabling performance analysis predictions for complex aircraft geometries). In order to ensure this degree of computational capability, the NAS program continues to implement the following efforts: (1) acquire pathfinding, state-of-the-art, high-speed processors (HSP's); (2) provide a uniform, balanced, user-friendly system with equivalent capabilities for local and remote users; (3) maintain an auxiliary processing center for secure processing; (4) research existing parallel architectures and incorporate them into future generations of the NAS; (5) develop a hardware and software environment for prototyping and testing of computers, networks, storage devices, workstations and graphic output devices; and (6) research and enhance an increasingly sophisticated system of hardware/software tools and environments to assist the user in performing CFD tasks efficiently.

During FY 1993, balanced system software and support for the HSP's are being achieved through a continuous upgrade process. The third high-speed processor (HSP-3), which replaces the original machine (HSP-1), will be placed in operation in March 1993. HSP-1 was returned to Cray Research as part of the negotiated contract for HSP-3 ($2.0 million credit to the HSP-3 contract). HSP-2 (a Cray Y-MP) was purchased completely in October 1992 (lease buyout option). HSP-3 will provide a fourfold increase in computational hours available to the NAS community. Mass storage capacity is 9.6 terabytes, enabling quickly available data storage consistent with HSP output capability. The AERONET, which links NAS capabilities to its customers, is operational. AERONET is the long-haul communications network which replaced older, switched networking with a newer routed (more reliable and efficient) network and increased traffic throughput speed by up to a factor of ten. The next generation workstation (WKS-III) request for proposal will be released in March 1993. The WKS-III is to provide a threefold improvement in workstation interface capability to the HSP's in FY 1994. To meet the challenge of providing increased operational computing capability for aerospace applications, pathfinding research

continues in parallel architectures and algorithms with mapping of specific aerodynamic simulation problems onto advanced computational platforms. The two NAS parallel machines are being upgraded from a Thinking Machines CM-2 to CM-5, and Intel Gamma to Paragon. During FY 1993, user interface and visualization software research emphasis is shifting toward multidisciplinary tools and requirements.

CHANGES FROM FY 1993 BUDGET ESTIMATE

This program reflects an increase of $0.9 million which resulted from the redistribution of ROS funds.

BASIS OF FY 1994 ESTIMATE

The number of accounts will be maintained around its current level (about 2000) continuing the diverse use of the system by NASA, the DOD, other Government agencies, industry and academia. During FY 1994, the next generation workstation (WKS-III) will be installed and become operational. The request for proposal for the fourth high-speed processor (HSP-4) will be released in FY 1994. HSP-4 is expected to provide another fourfold increase in capability over HSP-3. Other hardware and software elements of the extended operational configuration will continue to be enhanced as part of the continual process for development of future versions of the NAS.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
High-speed research.....	76,400	89,900	116,995	187,200

OBJECTIVES AND STATUS

Industry studies here and abroad have identified a substantial market for a future high-speed civil transport (HSCT) aircraft to meet the rapidly growing long-haul market, particularly the Pacific-rim sector where travel is projected to increase fourfold by the year 2000. Over the period from 2000 to 2015, industry estimates this market could support an estimated 500 to 1000 HSCT aircraft, thereby creating a multibillion dollar sales opportunity for its producers. While current technology is insufficient, the studies further indicate that an environmentally compatible and economically competitive HSCT could reach fruition through aggressive technology development and application. NASA's high-speed research program is providing a public-sector catalyst in addressing this important opportunity with U.S. industry through a two-phased approach. In order to ensure the commercial relevance of this program, a cost-shared partnership between NASA and industry will be sought wherever possible. Moreover, a program evaluation plan will be developed to identify timely independent reviews.

Phase I, a seven-year effort which began in FY 1990, is defining critical HSCT environmental compatibility requirements in the areas of atmospheric effects and community noise and sonic boom, and is establishing a technology foundation to meet these requirements. Progress to date has provided growing confidence that the necessary technology can be developed to satisfy the critical concerns. Most importantly, assessment results from the latest atmospheric models incorporating multiphase chemistry are now indicating that a fleet of 600 Mach 2.4 HSCT aircraft with advanced low-emission engines would cause virtually no impact in stratospheric ozone. In FY 1993, an interim assessment of the atmospheric effects of stratospheric aircraft is being submitted to the National Research Council for a critical review. The assessment is based on improvements of chemistry and dynamics simulations incorporated in the related atmospheric models. Flight tests of the Perseus autonomous aircraft will also be completed and two aircraft will be delivered for use in atmospheric measurement to continue the improvement and validation of the models.

Related laboratory testing of low-emission combustor concepts has also successfully achieved the desired reduced emission levels, with results even better than the program goal of five grams of nitrogen oxide (NOx) per kilogram of fuel. During FY 1993, the knowledge gained from this flame-tube level testing is being transferred to practical-application combustor sector hardware for experimental evaluation. Based on the results, configurations will be selected for both the lean premixed prevaporized and rich burn, quick quench, lean burn concepts to proceed with the verification of NOx reduction goals in full annular rigs that combine all of the similar components of an actual engine combustor.

In noise reduction, upwards of 18-decibel noise suppression has been achieved through advanced mixer-ejector nozzles, and wind tunnel testing of innovative high-lift devices shows an additional two- to six-decibel potential through advanced operational procedures. As a nominal, 20-decibel reduction is needed to achieve levels equivalent to the same stringent Federal Air Regulation 36 (FAR 36), Stage 3 noise standards required for today's new subsonic transport aircraft. There is growing confidence that community noise concerns can be satisfied. Testing of second-generation mixer/ejector nozzles, incorporating aerodynamic refinements and parallel acoustic treatment development, is continuing during FY 1993 to ensure the best selection of the top two engine configurations on an integrated noise and performance basis. Similarly, high-lift concept development is continuing to maximize its role in reducing aircraft system noise propagated to the community.

Although unlimited supersonic operation over land appears economically impractical based on wind tunnel model testing to date, the test results have shown the ability to soften the sonic boom with minimal penalty in aerodynamic efficiency. Small-scale aircraft model testing is thus continuing in FY 1993, but with a redirected objective of optimizing the performance of a configuration that could operate at Mach 1.6 to 2.4 along limited flight corridors over unpopulated regions.

Enabling propulsion materials research, initiated in FY 1992 to meet the requirements of high-temperature, low-emission combustors and low-noise exhaust nozzles, continues to focus on development of advanced ceramic matrix composite (CMC), metal matrix composite (MMC), and intermetallic matrix composite (IMC) materials. Primary and alternate combustor CMC materials have been selected and are being tested for mechanical and physical properties. Promising nondestructive evaluation (NDE) methods are also being assessed for their usefulness in characterizing the thermal-mechanical degradation of these CMC materials. In addition, coating requirements are being established for the combustor materials, and several coating approaches are under development. Primary and alternate nozzle IMC and MMC materials are also being assessed, and fiber/coating scale-up requirements and test methods are being defined. Analytical methods development continues to focus on heat transfer, constitutive and damage models, and life prediction methods. New high-temperature test systems which will provide unique capabilities for benchmark testing and long-term durability testing of combustor and nozzle materials are being installed and calibrated.

Based on this progress, the program has been expanded in FY 1993 to begin addressing the remaining technologies necessary to help the U.S. industry's competitive position to design an HSCT for operational introduction in the 2005 time frame. The objective of these Phase II efforts is to develop, in cooperation with U.S. industry, the high-leverage technologies also essential to economic viability. The $25 million added by Congress to the high-speed research FY 1993 budget has enabled initiation of the longest-lead, most critical Phase II areas -- advanced high-temperature, long-life materials for key airframe structures, and propulsion components for high fuel efficiency, as well as low noise and emissions. Key FY 1993 efforts include design and integration studies to assess the benefits and risks of advanced materials, structural concepts, and manufacturing approaches; development of a common set of structural design requirements and

baseline designs for both Mach 2.0 and Mach 2.4 aircraft, including a common data base of material property requirements; and development of both metallic materials (aluminum and titanium) and polymer matrix composites (PMC's), including initiation of long-term durability testing.

CHANGES FROM FY 1993 BUDGET ESTIMATE

High-speed research reflects a $27.1 million increase, $25.0 million of which resulted from Congressional action. As described above, this is being used to augment the ongoing program to initiate the highest priority areas in propulsion and airframe technology necessary for timely HSCT technology development. An additional $2.1 million was reallocated to this program as part of the redistribution of ROS funds.

BASIS OF FY 1994 ESTIMATE

With the full initiation of Phase II in FY 1994, the high-speed research program will be addressing the essential technologies needed by the U.S. aeronautics industry in order to make informed decisions regarding future HSCT development and production. Phase II is planned as an eight year effort. The technology foundation necessary to resolve critical environmental compatibility issues will continue to be developed, and will be complemented by additional efforts to also ensure economic viability.

Improved understanding of the atmospheric effects of stratospheric aircraft remains as a key area of emphasis in FY 1994. In collaboration with the airborne southern hemisphere ozone expedition, additional atmospheric measurements will be obtained for different latitudes than previously studied, including equatorial regions. New instruments developed for improved understanding of recent important heterogeneous chemistry hypotheses will be applied on the ER-2 aircraft platform, as well as on the first field deployment of the Perseus autonomous aircraft. The atmospheric modeling effort will emphasize evaluation of uncertainty in continuing assessments of aircraft effects on ozone and a first assessment of climatic effects. Recommendations from the FY 1993 National Research Council review of interim assessment activity will also be implemented as appropriate.

Propulsion component technology will be expanded in FY 1994 by building on the emissions and source noise reduction research, and by also increasing the efforts started in FY 1993 on high-performance inlets and fans. The lean premixed prevaporized and rich burn, quick quench, lean burn combustor flame-tube and sector rig test results will be used to begin the design of full annular combustor rigs for later testing to validate the low NOx capability for stable and efficient operation over the full range of conditions from startup, taxi and takeoff, through climbout, cruise and landing. In a parallel effort, preliminary design will begin for combustor experiments with a testbed engine. A second generation of model mixer/ejector nozzles will be evaluated in coordination with primary and backup engine selections that promise acceptable community noise levels and economical performance. Special consideration will be given to ejector acoustic liners to reduce mixing noise. The small-scale test results and supporting analyses will be used to begin

preliminary design of the two best nozzle concepts for large-scale experiments with testbed engines over the projected full range of operating conditions. Engine inlet technology will similarly be advanced with small-scale tests. In particular, the two-dimensional bifurcated inlet development will be initiated to bring this concept to the same level of maturity as the axisymmetric concept. A preliminary design of a high-flow fan will also be conducted.

Enabling propulsion materials development will continue to focus on combustor liner CMC's and nozzle IMC's and MMC's. The first annual technical program review will be conducted with industry participants in the spring, at which time progress in the development of primary and alternate combustor liner materials and design concepts will be assessed. Primary and alternate nozzle materials and design concepts will be selected in the summer based on design studies and characterization tests conducted over the past year. Scale-up of the primary CMC and IMC fiber/coating processes will be started, and the most promising CMC materials will be selected for component fabrication and test. Material selections will continue to be assessed on an ongoing basis as the requirements become better defined by the propulsion system trade studies.

Because of the durability challenges facing successful use of PMC's in high-temperature applications, initial efforts are focused on long-term durability testing of promising materials and on development of accelerated test methods. In addition, commercial and developmental polymers are being modified and evaluated for mechanical properties, durability, and processability. An assessment of low-cost processing methods for both metals and composites will also be initiated. Superplastic forming/diffusion bonding, laser welding, and brazing/diffusion bonding will be evaluated for producing low cost advanced titanium structures, and low cost forming and joining processes such as adhesive bonding, weld bonding, and rivet bonding will be evaluated for advanced high-temperature aluminum structures. Candidate composite materials will be assessed for their amenability to automated tape and tow placement, resin transfer molding, and thermoforming techniques, and the most promising high-temperature polymers will be developed as adhesives.

The airframe materials and structures technology effort will continue to focus on development and evaluation of both high-temperature metallic materials (aluminum and titanium) and PMC's. The focus in metallic materials is on promising new low-density and high-temperature aluminum alloys for use up to Mach 2.0, and on advanced titanium alloys (for use up to Mach 2.4) which offer specific properties that are 20-percent higher than conventional titaniums.

Aerodynamics technology efforts will be expanded by initiating wind tunnel testing of baseline aircraft design at transonic and supersonic conditions. Following these tests, computational analysis will be used to optimize the total wing-body configuration, including propulsion system integration, to evolve a second-generation design. In parallel, analytical and wind tunnel evaluations of low-boom, high-performance configurations will be conducted, and the assessment of human response to in-home exposure to simulated sonic booms will be completed. High-lift concept development will continue with computational and

experimental aerodynamic evaluations and assessment of the associated noise reduction. The most promising high-lift concepts will be readied for high-Reynolds number wind tunnel testing in the National Transonic Facility. Using knowledge gained from previous supersonic laminar flow flight research, the large suction panel for active aerodynamic control will be fabricated for planned flight testing on the F-16XL testbed in FY 1995.

Flight deck systems research and technology development will be initiated in FY 1994 to also provide for safe and efficient integration of a future HSCT in the international air transportation system. First-year efforts will concentrate on pilot information requirements and advanced cockpit displays for both the synthetic vision and flight management systems. Modeling of the HSCT aerodynamics, structural modes, and flight and propulsion controls will also begin in support of ground-based and in-flight simulations to be used throughout the development process in evaluating overall flying qualities.

Because of the high level of interdependency between the above technologies, system-level integration studies will continue in order to assure that environmental goals can be achieved in concert with economic viability.

Due to the continuing need for an instrument platform with greater altitude, duration and range capability, a technology program for unmanned aerospace vehicles will be initiated. Emphasis will be on propulsion systems suitable for operation in the rarefied upper atmosphere.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Advanced subsonic technology.....	5,000	12,300	12,425	101,300

OBJECTIVES AND STATUS

With competition from foreign competitors greatly increasing, technology is criticslly needed to help preserve the U.S. aeronsutics industry market share, jobs, and balance of trade. Exports in large commercial transports make a significant contribution to the U.S. balance of trade. However, industry estimates that the U.S. world-wide market share has slipped from a high of 91 percent during the 1960's to 67 percent in 1992. Increasing congestion in the aviation system and growing concerns about the environmental compatibility of aircraft may limit the projected growth in the market. According to the Federal Aviation Administration (FAA) 1991-1992 Aviation System Capacity Plan, delays due to weather and the volume of aircraft in the Air Traffic Control System cost U.S. operators more than $4.7 billion per year in excess fuel burn and additional operational costs during 1990. Noise curfews and inefficient engine emissions standards are expected to be required before the end of this century. In FY 1994, the Advances Subsonic Technology program will accelerate the broad-based NASA R&T program for subsonic aircraft by augmenting the focused development of high payoff technologies to enable a safe, highly productive global air transportation system that includes a new generation of environmentally compatible, economical aircraft that are superior to foreign products. In order to ensure the commercial relevance of this program for those projects benefiting industry, a cost shared partnership between NASA and industry will be sought wherever possible. Moreover, a program evaluation plan will be developed to identify timely independent reviews. The fly-by-light/power-by-wire (FBL/PBW) and aging aircraft elements began in FY 1992.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The advanced subsonic technology program reflects an increase of $0.1 million which resulted from the redistribution of ROS funds.

BASIS OF FY 1994 ESTIMATE

The advanced turboprop program (ATP), now focused solely on noise reduction, will be moved to Advanced Subsonic Technology (AST) and renamed as the noise reduction element. This element will be augmented beginning in FY 1994. The terminal area productivity (TAP), integrated wing design, propulsion, short-haul aircraft technology integration and environmental impact and environmental research aircraft and remote sensor technology elements will be initiated in FY 1994.

The ongoing FBL/PBW element is emphasizing development of analytical and experimental methods for assessing electromagnetic effects. In FY 1994, an experimental laboratory will be completed where analytical methods can be validated. Laboratory testing of critical optical and power components will be initiated in FY 1994.

During FY 1994, the ongoing aging aircraft program will complete the development of computational methods to predict multisite fatigue crack growth and the residual strength of aluminum airplane fuselages. Also in FY 1994, experimental validation of these methods will continue, and two NDE techniques used on large fuselage surface areas will be verified.

In FY 1994, the emphasis in noise reduction will continue to be the understanding and control of source noise mechanisms, propulsion/airframe installation aerodynamics, and the development of improved aerodynamic, structural and acoustic analysis techniques for ultra-high bypass subsonic propulsion systems. Testing and validation of selected fan and nacelle configurations addressing the impact of engine/airframe integration will be completed. The FY 1994 augmented effort will include validation of an aerodynamic and performance design code, definition of baseline engine noise sources, demonstration of active noise reduction concepts for a selected nacelle configuration, evaluation of novel installation concepts, and assessment of current airframe noise prediction capabilities.

In FY 1994, the terminal area productivity element will be initiated and will evaluate the potential for ground-to-aircraft data communications and dynamic spacing capabilities based on NASA's air traffic control automation efforts. Reduced separation requirements will be investigated by evaluating wake vortex issues and community noise constraints, as well as enhanced aircraft flight management systems.

The integrated wing program, to be initiated in FY 1994, will focus on technology that treats the aircraft aerodynamics in an integrated manner. In 1994, transport flight test data will be used to validate computational codes for the evaluation of high-lift systems. Additionally, a semispan, large-scale transonic wind tunnel test will evaluate propulsion airframe integration. This effort will build upon and integrate the fundamental concepts and component technologies being addressed in the propulsion and power research and technology base program.

Within the short-haul aircraft element being initiated in FY 1994, tiltrotor tests will be conducted utilizing the XV-15 and vertical motion simulator to determine noise characteristics and to investigate the terminal area flight procedures that can be employed to control the radiated noise patterns. Also in FY 1994, wind tunnel tests and computational studies on integrated aerodynamics and structural concepts for a new class of short-haul aircraft will be undertaken. New cockpit technology for this class of aircraft will be initiated.

In FY 1994, the advanced propulsion element will be initiated and will focus on establishing specific engine concepts and configurations which reflect industry's vision of the next-generation high-bypass-ratio turbofans.

Systems analyses efforts to be initiated in FY 1994 within the technology integration and environmental impact element will establish an integration team and framework for integrating analytical methods. In-house modeling capabilities for aircraft, engines and air traffic control economics will be improved. An initial systems analysis will be performed to assess technology status and impact integrated aviation system components. The scientific modeling and assessment effort underway for aircraft emissions into the stratosphere will be expanded to include upper troposphere altitudes typical for subsonic transport operations. This effort will include development of advanced instrumentation and remote sensor technology for use on existing and new research aircraft. The composites element will be initiated in FY 1995. All projects have identified end dates so to enable the possibility of new promising technology projects.

BASIS OF FY 1994 FUNDING REQUIREMENT

RESEARCH OPERATIONS SUPPORT

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Research operations support.....	232,800	243,200	148,875	143,500

OBJECTIVES AND STATUS

Research Operations Support (ROS) funding provides vital support to the civil service workforce and to the physical plant at the Centers and at NASA Headquarters. This funding supports the basic core administrative functions such as personnel, payroll, accounting, procurement and legal counsel. It also supports centerwide services for civil service staff, such as mail, telephones, janitorial services, transportation, medical (other than astronaut), security, and fire protection, as well as maintenance of roads, grounds, and all requirements of administrative buildings. Funding to support activities which directly benefit all NASA programs is included in the program budgets.

CHANGES FROM FY 1993 BUDGET ESTIMATE

In FY 1992, establishment of the ROS was initially accomplished by transferring funds contained in the Operation of Installation account in the Research and Program Management appropriation to the Research and Development and Space Flight, Control and Data Communications appropriations. During FY 1993, a more detailed examination of activities supported by ROS funding was conducted by the program offices to identify those directly related to programmatic activities. Funding for activities dedicated to a single program was transferred to the benefiting program. In total, the decrease in ROS funding reflects the transfer of $82.3 million consistent with the restructuring activity and a reduction of $14.3 million consistent with Congressional direction to reduce ROS, which has been partially offset by the addition of $2.3 million for financial management system upgrades at the Ames, Langley, and Lewis Research Centers.

BASIS OF FY 1994 ESTIMATE

The FY 1994 estimate reflects the necessary funding to support administrative and facility maintenance requirements at the NASA Centers and NASA Headquarters. This includes administrative services that support allcivil service employees, facility maintenance, maintenance of roads, grounds and requirements of administrative buildings.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1994 ESTIMATES

BUDGET SUMMARY

OFFICE OF AERONAUTICS

TRANSATMOSPHERIC RESEARCH AND TECHNOLOGY

SUMMARY OF RESOURCES REQUIREMENTS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate	Page Number
		(Thousands of Dollars)			
Transatmospheric research and technology	4,136	80,000	--	80,000	RD 10-2
Distribution of Program Amount by Installation					
Ames Research Center	901	2,400	--	4,000	
Langley Research Center	2,250	4,800	--	7,000	
Lewis Research Center	893	3,200	--	5,000	
Marshall Space Flight Center	10	100	--	--	
Headquarters	82	69,500	--	64,000	
Total	4,136	80,000	--	80,000	

OFFICE OF AERONAUTICS

TRANSATMOSPHERIC RESEARCH AND TECHNOLOGY

OBJECTIVES AND JUSTIFICATION

The Transatmospheric Research and Technology program is the NASA portion of the joint NASA/Department of Defense (DOD) National Aero-Space Plane (NASP) program. The program objective is to develop and then demonstrate the technology required to permit the Nation to develop reusable, single-stage-to-orbit (SSTO) vehicles with airbreathing primary propulsion as well as horizontal takeoff and landing. The extremely short duration, non-real gas test conditions available in hypersonic ground test facilities cause considerable uncertainty about very high Mach hypersonic flight, especially scramjet engine performance. To reduce technology risk hypersonic flight experiments are being examined to validate ground-based computational and wind tunnel data.

The exceptionally broad technology base includes propulsion, materials and structures, control, and applications of computational fluid dynamics. High-risk program elements (primarily aeropropulsion) and hypersonic flight tests of critical technology elements are the near-term focus.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The NASA FY 1993 Transatmospheric Research and Technology program funding was removed (without prejudice) by the Congress. Consequently, the program was restructured, using DOD funding, to begin focusing more on the hypersonic propulsion system, the highest risk area. DOD funds were also used in FY 1993 to support the execution of a variety of critical technology development tasks at NASA Centers.

BASIS OF FY 1994 ESTIMATE

During 1994, ground-based testing of the ramjet/scramjet concept development engine (CDE) will continue at the NASA Langley Research Center, and will focus on propulsion technologies and the initiation of hypersonic flight test experiments such as rocket boosted experiments. A series of specific technology-development tasks assigned to NASA Research Centers will continue to utilize the unique expertise of NASA personnel; in other areas, NASA will continue to support technology-development tests by contractors in its facilities.

Work on propulsion will grow to include more sophisticated tests of refined engine components and more complete engine models. Ground tests of large-scale engine models will provide key data for equivalent flight speeds of up to Mach 8 in FY 1994. In preparation for hypersonic flight experiments, component tests will be pursued at simulated flight speeds of Mach 18. Such tests will provide the performance for data for engine-cycle concepts in scramjet, as well as ramjet-to-scramjet transition modes, for the engine configuration which will be tested during the subsequent flight experiments. Work on engine materials and structures, including actively cooled sections and engine aeroelastic behavior, will lead to refinements in the scramjet engine design.

Airframe work will focus on documentation of the initial airframe design, advanced materials characterization and large-scale structural tests in support of hypersonic flight experiments. Lightweight metal-matrix composites will be more completely characterized. Thermo-mechanical tests of fuselage panels and actively cooled assemblies, which will be subjected to many cycles of simulated hypersonic flight conditions, will be completed. Key test data will be provided on flight experiment engine/airframe integration.

Computational fluid dynamics (CFD) will continue to play a vital role in both external and internal (propulsion-type) flows. CFD advancement in FY 1994 will further augment design/analysis processes for complex flows such as those found in the scramjet combustor.

Initial work will be aimed at flight experiments to reduce technological risk in the prediction of both hypersonic boundary-layer transition (laminar-to-turbulent) and of scramjet performance. A number of flight tests are likely. Concept design, systems operations, instrumentation and other activities will be pursued to support initial hypersonic flight experiments

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1994 ESTIMATES

BUDGET SUMMARY

OFFICE OF SAFETY AND MISSION QUALITY — SAFETY, RELIABILITY, MAINTAINABILITY AND QUALITY ASSURANCE

SUMMARY OF RESOURCES REQUIREMENTS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate	Page Number
		(Thousands of Dollars)			
Safety, reliability, maintainability and quality assurance	33,600	32,500	32,707	35,300	RD 11-2
Total	33,600	32,500	32,707	35,300	
Distribution of Program Amount by Installation					
Johnson Space Center	3,914	2,260	2,936	2,140	
Kennedy Space Center	1,818	1,925	1,101	1,925	
Marshall Space Flight Center	2,636	1,895	2,059	1,660	
Stennis Space Center	620	860	713	480	
Goddard Space Flight Center	4,268	3,270	4,591	2,771	
Jet Propulsion Laboratory	5,370	4,389	3,126	1,390	
Ames Research Center	150	271	221	350	
Langley Research Center	2,282	1,665	2,107	2,066	
Lewis Research Center	4,232	3,480	3,982	4,136	
Headquarters	8,310	12,485	11,871	18,382	
Total	33,600	32,500	32,707	35,300	

OFFICE OF SAFETY AND MISSION QUALITY SAFETY, RELIABILITY, MAINTAINABILITY AND QUALITY ASSURANCE

OBJECTIVES AND JUSTIFICATION

The goal of the Office of Safety and Mission Quality (OSMQ) is to assure the safety and quality of NASA missions. This is achieved through the development, implementation, and oversight of Agencywide safety, reliability, maintainability, and quality assurance (SRM&QA) policies and procedures. In addition, OSMQ conducts independent technical assessments of all major flight and nonflight projects to determine compliance to SRM&QA requirements. The SRM&QA functions include program assurance; development of technical standards and demonstration of key technologies for improving program assurance; safety; systems assessments and trend analyses; risk identification and resolution; reliability, maintainability, and quality assurance; and quality management initiatives.

OSMQ is dedicated to conducting NASA programs within an acceptable level of risk and providing NASA leadership in quality management of science and engineering programs.

The objectives of the NASA OSMQ are to:

- Coordinate the activities of NASA's SRM&QA offices, providing advice to the Administrator on key safety and mission assurance issues.
- Develop and implement NASA-wide risk management practices.
- Integrate SRM&QA requirements at the earliest possible stage of a program or project.
- Develop and advance engineering and SRM&QA standards and practices.
- Provide NASA leadership for the development of software independent verification and validation (IV&V) techniques.
- Develop and advance SRM&QA presence in NASA programs and operations.
- Serve as an advocate for NASA-wide SRM&QA functions.

The office is involved across all levels of NASA programs to provide SRM&QA leadership. A key function is to provide independent judgments of program decisions and issues based on SRM&QA analyses, particularly where there is divergent engineering opinion on critical points or a high degree of uncertainty that could impact program safety and mission success. OSMQ ensures that SRM&QA requirements are integrated into the earliest phases of development for space and aeronautics programs. Conformance with SRM&QA policies and procedures is monitored through each program phase to assure proper attention to risk. Through SRM&QA surveys and Functional Management Reviews (FMR's) of the NASA Centers, SRM&QA program implementation is assessed.

In the area of Safety, OSMQ develops top-level safety policies, defines program-specific safety requirements, and identifies risks. A primary means of supporting the NASA risk management process is to conduct hazard analyses and quantitative risk assessments to identify and resolve safety threats to NASA flight programs and facilities. OSMQ also performs trend analyses using mission performance and problem data to identify/predict areas that require preventive measures, or corrective actions to assure reliable and maintainable spacecraft. NASA operational safety considerations also include crew safety, range safety, mishap investigations, and implementation of federal safety requirements.

OSMQ's Program Assurance organization serves as the primary interface between OSMQ and NASA Headquarters program offices. Key functions are to establish program-level SRM&QA requirements to address the unique mission, design, and operational characteristics of each program and to ensure compliance with Agency SRM&QA policies. The program assurance organization maintains rigorous oversight of large-scale, complex operations such as the Space Shuttle program and the Space Station program.

In the Technical Standards area, OSMQ develops and maintains engineering standards and capabilities required to enhance the safety, reliability, and performance of NASA missions. OSMQ supports the establishment of NASA-wide standards and practices for design, manufacture, and test of flight systems. Support is also provided for development and demonstration of applied technologies. Key areas of emphasis include aerospace batteries, spacecraft wiring, and pyrotechnic devices. Results from these program activities support the development of future space projects and will lead to improvements in overall mission capability. Planning and managing NASA's transition to the metric system is also supported.

In recognition of the Agency's increasingly complex software requirements, the comprehensive OSMQ software assurance program addresses mission-essential software systems. The office assures that methods, processes, and tools to evaluate software quality are maintained current with the demands of advanced systems. OSMQ evaluates and improves NASA's software engineering processes and products through development of standards and measures and through promotion of technology transfer. OSMQ strives to fully integrate software engineering and assurance into the systems development and operations process.

OSMQ supports NASA programs in the area of Quality Assurance. These efforts include development of standards for parts quality and product assurance, materials treatments and processes, microcircuit radiation effects evaluations, and nondestructive evaluation techniques.

Under its Quality Assurance responsibilities, OSMQ also has supported information gathering and qualification for electrical, electronic, and electromechanical (EEE) spacecraft parts and electronic packaging techniques and a certification program for mechanical parts.

CHANGES FROM FY 1993 BUDGET ESTIMATE

A reduction of $1.0 million has been applied in FY 1993 to the SRM&QA program in response to the Congressionally-directed general reduction of $2.0 million to SRM&QA and Academic programs. This led to reduction of the test and qualification program for radiation-hardened parts to be used in NASA spacecraft.

This reduction is offset by a $1.2 million increase due to the redistribution of Research Operations Support (ROS) funding.

BASIS OF FY 1994 ESTIMATE

In FY 1994, OSMQ will continue its initiatives to provide support to the Agency in SRM&QA oversight and direction, and continue to monitor the performance of NASA flight programs. Initiatives to improve NASA use of system engineering, software IV&V, risk methods, and assurance standards and practices will continue.

OSMQ will initiate management of the new NASA IV&V Center in Fairmont, West Virginia, upon its completion in FY 1994. This office will provide overall direction and operations management of the center, including support for research and development of software IV&V techniques and standards.

Another initiative of OSMQ is to conduct a pilot program to enhance the office's direct support of NASA development programs. This initiative is intended to refine methods and techniques for early OSMQ involvement in flight program design and trade-off analysis.

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RESEARCH AND DEVELOPMENT

FISCAL YEAR 1994 ESTIMATES

BUDGET SUMMARY

ACADEMIC PROGRAMS

SUMMARY OF RESOURCES REQUIREMENTS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate	Page Number
		(Thousands of Dollars)			
Educational affairs.....	29,800	33,700	56,800	36,800	RD 12-1
Space grant college and fellowship.....	15,000	15,000	13,400	14,500	RD 12-12
Minority university research.....	22,000	22,700	22,700	23,200	RD 13-1
Total.....	66,800	71,400	92,900	74,500	

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1994 ESTIMATES

BUDGET SUMMARY

ACADEMIC PROGRAMS

EDUCATIONAL AFFAIRS

SUMMARY OF RESOURCES REQUIREMENTS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate	Page Number
		(Thouasnds of Dollars)			
Grsduate student researchers.....	7.000	8.200	7.000	7.600	RD 12-3
Summer faculty fellowship.....	4.000	4.000	3.900	4.100	RD 12-4
Innovative research.....	2.900	3.100	2.900	3.000	RD 12-5
Miasion to planet earth/JOVE.....	2.800	2.800	2.600	2.700	RD 12-6
Aerospace education services (ASEP)....	6.100	7.000	6.500	6.900	RD 12-7
Innovative education.....	5.500	7.600	5.300	6.000	RD 12-8
Educational technology.....	1.500	1.000	4.200	1.500	RD 12-9
Special projects.....	--	--	19.400	--	RD 12-10
EPSCoR.....	--	--	5.000	5.000	RD 12-11
Total.....	29,800	33,700	56,800	36,800	
Distribution of Program Amount by Installation					
Johnson Space Center.....	1.247	1.277	1.355	1.200	
Kennedy Space Center.....	1.126	1.156	1.270	1.100	
Marshall Space Flight Center.....	1.387	1.480	1.525	1.310	
Stennia Space Center.....	920	1.150	1.253	940	
Goddsrd Space Flight Center.....	1.210	1.240	1.280	1.230	
Jet Propulsion Laboratory.....	1.146	1.176	1.250	1.120	
Ames Reaearch Center.....	1.280	1.310	1.365	1.287	
Langley Research Center.....	1.334	1.390	1.397	1.290	
Lewis Research Center.....	1.350	1.445	1.505	1.305	
Headquartera.....	18.800	22.076	44.600	26.018	
Total.....	29,800	33,700	56,800	36,800	

ACADEMIC PROGRAMS

EDUCATIONAL AFFAIRS

OBJECTIVES AND JUSTIFICATION

The goal of NASA's Education program is to promote excellence in America's education system through enhancing and expanding scientific and technological competence. This program directly supports three of the National Goals for Education, including goal number four that states by the year 2000, U.S. students will be the first in the world in science and mathematics achievement. NASA's program is designed to capture and channel student interest in science, engineering, mathematics, and technology, as well as enhance teacher and faculty knowledge and skills related to these subjects. These Agencywide pre-college, university and minority university programs are in support of NASA's education mission to ensure a sufficient talent pool to preserve NASA and U.S. leadership in aeronautics, space and Earth science, and technology and to help meet the National Education Goals.

The specific objectives of the Educational Affairs program are:

- To communicate to the pre-college educational community -- students, teachers, and administrators -- a better understanding of the knowledge derived from NASA research and development and its application to the study of mathematics, science, and technology;

- To encourage elementary level students to take greater interest in mathematics, science, and technology through the use of advanced instructional technology, development of strong teacher resource centers, curriculum materials designed for the elementary level, and the initiation of cooperative relationships with private industry, local school systems, and community organizations;

- To significantly increase the number of highly trained scientists and engineers in aeronautics, space science, space applications, and space technology to meet the continuing needs of the national aerospace effort;

- To facilitate the direct interaction, further the professional knowledge and stimulate the exchange of ideas between university faculty members and NASA scientists and engineers;

- To support innovative research at U.S. institutions of higher learning that is in the formative or embryonic stage and that would appear to have significant potential to advance space science and applications programs;

- To provide for the development and use of a core, long-term U.S. national university capability to conduct multiyear, Earth science discipline-oriented applied research and remote sensing; and

- To explore the application of state-of-the-art technologies to enhance teaching methods and improve dissemination of education program materials.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The net increase of $23.1 million in FY 1993 includes an increase of $22.2 million for special projects, specifically directed by Congress, an increase of $5 million to initiate the NASA Experimental Program to Stimulate Competitive Research (EPSCoR) consistent with Congressional direction contained in the FY 1993 NASA Authorization Act (P.L. 102-588), offset by a reduction of $1 million as part of a general reduction to Safety, Reliability and Quality Assurance/Education programs directed by Congress, and a further reduction of $3.1 million to offset the increases specified above.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Graduate student researchers.....	7,000	8,200	7,000	7,600

OBJECTIVES AND STATUS

The Graduate Student Researchers program, initiated in 1980, provides graduate fellowships nationwide to post-baccalaureate U.S. citizens to conduct thesis research at a NASA Center or to carry out a program of study or research at their home institution. Awards are made to graduate students for a maximum of three years. On an annual basis, NASA supports approximately 500 graduate students pursuing the masters or doctorate degrees in science, engineering, mathematics, and technology.

CHANGES FROM FY 1993 BUDGET ESTIMATE

Funding is reduced to partially offset the mandated appropriation requirements from Congress. This will result in maintaining the number of new fellowships awarded in FY 1993 at the FY 1992 level.

BASIS OF FY 1994 ESTIMATE

The FY 1994 request will support additional fellowships at the graduate level, increasing the number of annual awards available yearly at each NASA Center.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Summer faculty fellowships.....	4,000	4,000	3,900	4,100

OBJECTIVES AND STATUS

The NASA Summer Faculty Fellowship program has completed 29 years of operation. This program provides highly beneficial opportunities for engineering and science faculty throughout the United States to participate in NASA research. This program has contributed significantly to the improvement of both undergraduate and graduate education, and directly benefited NASA, universities, faculty, students, and the Nation.

The Summer Faculty Fellowship program enables university faculty to spend ten weeks working directly with scientista and engineers at NASA Centers on problems of mutual interest. Participants must have a minimum of two years teaching experience and must be citizens of the United States. The program is designed to further the professional knowledge of faculty members, to stimulate an exchange of ideas between participants and NASA, and to enrich the research and teaching activities of the participanta' home institutions. This activity is operated cooperatively with the American Society for Engineering Education (ASEE).

Approximately 300 university faculty are supported annually for ten weeks. Evaluations conducted by ASEE of the program indicate that approximately 30-40 percent of the participating faculty subsequently receive NASA research grants or contracts.

CHANGES FROM FY 1993 BUDGET ESTIMATE

Funding is reduced to partially offset mandated appropriation requirements from Congress, and will reduce the number of new faculty fellowships awarded in FY 1993.

BASIS OF FY 1994 ESTIMATE

The FY 1994 funding level supports the award of increased new faculty fellowahips.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Innovative research.....	2,900	3,100	2,900	3,000

OBJECTIVES AND STATUS

A key to the future health and well-being of the Planetary Science and Astrophysics and Mission to Planet Earth programs lies in having the capacity to explore new ideas or novel technical approaches to research. The Innovative Research program is managed through the Offices of Space Science and Mission to Planet Earth to support research which, while still in its formative stage, has already demonstrated potential for significant advances for Planetary Science and Astrophysics and Mission to Planet Earth programs. The program is intended to provide a mechanism for the funding of scientifically sound proposals which might not be funded through normal channels either because of their interdisciplinary nature or because they are speculative or risky. The long-term goal is to help the new ideas mature to a state of acceptability within particular science discipline resources.

Announcements of the availability of funds and NASA's interest in receiving proposals for this type of research have been issued in 1980, 1982, 1985, 1988, and 1991. Emphasis in the program is on the support of innovative research at universities and colleges where involvement of students and new Ph.D. scientists can be enhanced. The program also emphasizes support to new researchers who have only recently completed graduate training. The primary criterion for inclusion in the program has been originality and the promise for innovation of the work being proposed. Over the past several years, a number of major technical advances have resulted from research supported by this program, such as the development of new infrared detector technology using nonstandard scientific approaches, the evolution of RNA enzymes in the laboratory, design of a magnetospheric imager proposed for the Cassini Saturn orbiter, a high pressure Xenon drift chamber for gamma-ray astronomy, varied line space extreme ultraviolet and x-ray gratings, and micro channel plate detectors.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The reduction of $200 thousand is required to offset the mandated appropriation requirements from Congress, and will defer award of some planned new research activities.

BASIS OF FY 1994 ESTIMATE

The FY 1994 funding will provide for continuation of support for 24 projects selected in 1991 and a reduced number of new awards to be initiated.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Mission to planet earth/JOVE.....	2,800	2,800	2,600	2,700

OBJECTIVES AND STATUS

In FY 1994, the Joint Venture (JOVE) program will be combined with research activities funded under the Mission to Planet Earth program. The JOVE program supports research and education activities at universities not traditionally involved in NASA's research activities. Fifty-five academic institutions in 37 states and Puerto Rico are currently participating. The Mission to Planet Earth program established a geographically distributed network of universities responsible for conducting research and development in remote sensing data applications, Earth sciences and Earth resources management. By combining these two efforts, NASA will provide research data to a broader range of academic institutions in exchange for faculty and student research time, and will establish and maintain multidisciplinary academic research and training programs for space and Earth sciences. Funding for Mission to Planet Earth research will be transitioned to support the expanded JOVE program over the next three years.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The reduction of $200 thousand is required to offset the mandated appropriation requirements from Congress. The FY 1993 reduction will result in deferral of some activities in the transition between Mission to Planet Earth and JOVE as well as the planned addition of participating institutions under JOVE.

BASIS OF FY 1994 ESTIMATE

In FY 1994, research activities funded under the JOVE and Mission to Planet Earth programs will continue NASA research data available to a broad range of academic institutions, and focus on working with the university community to prepare for the availability of space-based remote-sensing data from the U.S. Global Change program. Faculty at institutions with limited prior involvement in NASA research are encouraged to become members of research teams at NASA Field Centers and established mentor institutions. The JOVE program also promotes educational outreach and provides for the dissemination of space science information at various education levels.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Aerospace education services (AESP)....	6,100	7,000	6,500	6,900

OBJECTIVES AND STATUS

The Aerospace Education Services Program (AESP), also known as Spacemobile, is NASA's premier outreach program. The AESP specialists, all former science, math, or technology teachers, capture the interest of millions of students and enhance the teaching skills of teachers each year by using aeronautics and space as a catalyst in the teaching of science, mathematics, and technology. From September to June, AESP specialists visit schools throughout the United States, conducting student assemblies and teacher workshops. During the summer, AESP specialists conduct teacher workshops at the NASA Centers and various colleges and universities.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The reduction of $500 thousand is required to offset the mendated appropriation requirements from Congress. The FY 1993 reduction will eliminate some education outreach programs from the field centers to their respective regions, as well as curtail aerospace specialists school visits throughout the United States to provide teacher in service and conduct student assemblies.

BASIS OF FY 1994 ESTIMATE

The FY 1994 funding will allow for continuation of the current program, with increased funding targeted toward adding additional specialists and upgrading aerospace models and vans. Activities for FY 1994 include development of instruction media, program evaluation activities, and expansion of the Urban Community Education program to reach additional inner city communities.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Innovative education.....	5,500	7,600	5,300	6,000

OBJECTIVES AND STATUS

The Innovative Education program includes a series of programs targeted at both pre-college teachers and students. The goal is to enhance and improve the teaching of science, mathematics, and technology at the elementary and secondary level by using aeronautics and space as a theme and motivational factor. Programs included are: NASA Education Workshops for Math and Science Teachers (NEWMAST), NASA Education Workshops for Elementary School Teachers (NEWEST), the Space Science Student Involvement Program (SSIP), Summer High School Apprentice Program (SHARP), and community colleges. Program responsibility for the Teacher Resource Center Network (TRCN) has been transferred to Educational Technology.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The reduction of $2.3 million reflects the transfer of $500 thousand for the Teacher Resource Center Network (TRCN) consistent with program management responsibilities, and an additional reduction of $1.8 million to partially offset the mandated appropriation requirements from Congress. As a result of the reduction, the planned expansion of the Summer High School Apprenticeship Program (SHARP) Plus Program and the community college program developed in response to congressional direction will be implemented at a reduced rate. In addition, the number of teachers participating in the Teacher Workshops for Elementary School Teachers/NASA Education Workshops for Math and Science Teachers (NEWEST/NEWMAST) will be reduced. New initiatives planned to expand NASA's education outreach efforts will be deferred.

BASIS OF FY 1994 ESTIMATE

The FY 1994 funding will allow or the continuation of NASA-sponsored teacher workshops (NEWEST/NEWMAST), and student involvement programs (SHARP, SSIP). Development and implementation of various programs with community colleges to ensure the continuation of quality technicians for the aerospace effort, and for development of curriculum materials which relate to NASA missions that can be used in the classroom will also be continued.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Educational technology.....	1,500	1,000	4,200	1,500

OBJECTIVES AND STATUS

NASA's Education Technology effort is an essential component of the Agency's Education program. Educational technology products and services produced will ensure that NASA is able to develop the same level of leadership in technology education as it has in aeronautics and space technology. Additionally, the 21st Century Classroom, a component of the Classroom of the Future, will serve as a research and evaluation center where students and their teachers can utilize advanced educational technologies. Educational technology comprises the major element of the NASA dissemination plan.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The increase in FY 1993 reflects the transfer of $500 thousand for the Teacher Resource Center consistent with program management responsibilities, the addition of $2.8 million for Classroom of the Future as directed by Congress, and a reduction of $100 thousand to partially offset the mandated appropriations requirements by Congress.

BASIS FOR FY 1994 ESTIMATE

The FY 1994 funding will allow for the development of several technology-based products of high priority to the Education Division. These include a videodisk for Earth systems science, a feasibility study of a telecourse for teachers, and enhancements to the Spacelink Computer Information system. Funding will be used for NASA Select educational video programming, expansion of the Regional Teacher Resource Center Network, hands-on participatory science using computers and telecommunication systems, and the Classroom of the Future.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Special projects.....	--	--	19,400	--

CHANGES FROM FY 1993 BUDGET ESTIMATE

The increase in FY 1993 represents funding for specific projects directed by Congress in the Conference Report (House Report 102-902) accompanying the VA-HUD-Independent Agencies Appropriations Act (P.L. 102-389). These projects are:

Nebraska Department of Education	-	Expand NASA Teacher Resource Room ($0.4 million)
Oregon Systems of Higher Education	-	Computer Network Infrastructure ($4.5 million)
Oregon State University	-	Marine Science Center ($0.5 million)
Kansas Cosmosphere	-	Informal science activity at planetarium ($4 million)
University of Utah	-	Intermountain Network and Scientific Computation Center ($10 million)

In addition, $2.8 million is included in Educational Technology for Classroom of the Future, consistent with direction contained in House Report 102-902.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
EPSCoR.....	--	--	5,000	5,000

OBJECTIVES AND STATUS

Title III of the FY 1993 NASA Authorization Law (P.L. 102-588) directs NASA to establish a "competitive program to strengthen the competitive research capacity in those geographic areas of the NASA which are not currently fully competitive". This program, modeled after the National Science Foundation's Experimental Program to Stimulate Competitive Research (EPSCoR), will use the existing EPSCoR network to allow these states, which are not strong competitors for research funds, to strengthen their ability to compete for research grants in areas of research important to the mission of NASA. This program will be closely coordinated with the Space Grant College and Fellowship program. Many of the Space Grant College program Phase II consortia are also EPSCoR states.

CHANGES FROM FY 1993 ESTIMATE

NASA has reallocated $5 million to initiate this program. In FY 1993, efforts will focus on the design of the program, as well as make first grants.

BASIS FOR FY 1994 ESTIMATE

The FY 1994 funding will continue implementation of NASA's Experimental Program to Stimulate Competitive Research on Space and Aeronautics by renewing the grants made in FY 1993. These grants facilitate the building of research capability and improve the education environment of states that are not currently competitive for the research and education activities of NASA.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1994 ESTIMATES

BUDGET SUMMARY

ACADEMIC PROGRAMS

NATIONAL SPACE GRANT COLLEGE AND FELLOWSHIPS

SUMMARY OF RESOURCES REQUIREMENTS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Space grant college and fellowships....	15,000	15,000	13,400	14,500
Distribution of Program Amount by Installation				
Headquarters.....	15,000	15,000	13,400	14,500
Total.....	15,000	15,000	13,400	14,500

OBJECTIVES AND STATUS

The Space Grant College and Fellowship program is composed of three principal and interrelated elements: Designated Space Grant Colleges/Consortia, Space Grant Program Consortia, and Space Grant Capability Enhancement Consortia. Designated Space Grant Colleges/Consortia, of which 21 were selected in 1989 are preeminent institutions which are substantially involved in a broad spectrum of NASA research, offer advanced study in aerospace fields, and are significantly involved in related public service. Designated Colleges/Consortia each received $75,000 in start-up funds in FY 1989 and from $250,000-$325,000 in FY 1990 and 1991, depending on consortium affiliations. In FY 1992 and 1993 Designated schools received from $295,000-$380,000, which includes $20,000 augmentation to all schools, and a chance to receive additional funding of $35,000 depending upon the size of the consortium. In FY 1991, a new competition took place: consortia within states not represented by Designated Colleges/Consortia were invited to apply either for Program Grants or for Capability Enhancement Grants (the difference between the two types of programs related to current involvement in aerospace fields). Twenty-nine proposals were received. Of those 29, 14 were funded as Program Grants, 12 as Capability Enhancement Grants and three as planning grants. Selections were announced in February 1991. Program Grant and Capability Grant awardees received $150,000 in FY 1991,

a portion of which was to be used for fellowships. In FY 1992, the states received an additional augmentation of $20,000, with a chance to receive an additional $35,000, depending upon the size of the consortium. The three states, which received planning grants of $25,000 each were brought into the program as fully-funded proposals, along with Vermont and Puerto Rico, in FY 1992.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The $1.6 million reduction is required to partially offset the mandated appropriation from Congress. The reduced funding level requires that continuing and new initiatives, such as new designation status for Program Grant consortia, funding for unsolicited proposals, and the proposed Space Grant Centers for Excellence in Undergraduate Training, will have to be deferred.

BASIS OF FY 1994 ESTIMATE

The FY 1994 funding will continue implementation of the National Space Grant College and Fellowship program by funding the original 21 consortia and to fully fund 31 Phase II grantees. Funds will also be used to perform critical program evaluation which includes site visits to Space Grant College campuses and to convene the legislatively-mandated Space Grant Review Panel.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1994 ESTIMATES

BUDGET SUMMARY

ACADEMIC PROGRAMS

MINORITY UNIVERSITY RESEARCH AND EDUCATION PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate	Page Number
	(Thousands of Dollars)				
Historically black colleges and universities	11,000	11,400	11,400	12,200	RD 13-4
Other minority universities	4,700	4,800	4,800	4,532	RD 13-6
Graduate student researchers program (underrepresented minority focus)	3,300	3,400	3,400	3,368	RD 13-7
Undergraduate student researchers program (Underrepresented minority focus)	3,000	3,100	3,100	3,100	RD 13-8
Total	22,000	22,700	22,700	23,200	

Distribution of Program Amount by Installation

Johnson Space Center	2,543	941	1,559	1,474
Kennedy Space Center	--	260	--	--
Marshall Space Flight Center	450	814	980	922
Stennis Space Center	70	340	100	100
Goddard Space Flight Center	544	850	746	722
Jet Propulsion Laboratory	--	700	900	900
Ames Research Center	20	512	157	150
Langley Research Center	2,286	1,186	1,203	1,024
Lewis Research Center	495	716	366	362
Headquarters	15,592	16,381	16,689	17,546
Total	22,000	22,700	22,700	23,200

ACADEMIC PROGRAMS

MINORITY UNIVERSITY RESEARCH AND EDUCATION PROGRAM

OBJECTIVES AND JUSTIFICATION

One of the national goals in science and education is to expand the number of women and minority graduate and undergraduate students receiving degrees in math, science, and engineering. NASA is committed to expanding opportunities for talented students from underrepresented groups pursuing degrees in engineering and science disciplines. The goal of the NASA Minority University Research and Education programs is to expand the pool of talented students to include more women and members of underrepresented minority groups, through a strong alliance between Historically Black Colleges and Universities, Other Minority Universities, majority research institutions, elementary and secondary schools, industry and other Federal R&D agencies. Funding to Historically Black Colleges and Universities and other Minority Universities supports the strengthening of the research capabilities and infrastructure of these institutions, to make them competitive for mainstream NASA research funding. NASA provides support through research opportunities and fellowships underrepresented graduate and undergraduate students who are pursuing degrees in science and engineering fields. An additional responsibility for NASA and the Minority University Research and Education Division (MURED) will be to strengthen relationships with teacher training and enhancement activities in collaboration with minority universities and school systems. This effort will ensure that opportunities for K-12 teachers and students at elementary and secondary schools with significant minority enrollments are enhanced under Executive Order 12821, entitled "Improving Mathematics and Science Education in Support of the National Educational Goals."

NASA's Historically Black Colleges and Universities initiative is mandated by Executive Order 12677, which requires Federal agencies to increase significantly the involvement of Historically Black Colleges and Universities in Federally sponsored programs. Congress also directed NASA in FY 1985, to build closer relationships with universities that tend not to be major research institutions, but do have significant minority enrollments. To accomplish this goal, the Agency has established the Other Minority Universities (OMU) program to focus on meeting NASA's research objectives, and concurrently, increase the number of individuals from underrepresented groups in the pool of graduate researchers while not diminishing the Agency's effort toward Historically Black Colleges and Universities. Additionally, under the auspices of the Other Minority Universities program, NASA is responsive to Executive Order 12729 on Educational Excellence for Hispanic Americans, which directs Federal agencies to be actively involved in helping advance educational opportunities for Hispanic Americans.

NASA implements both the Historically Black Colleges and Universities and Other Minority Universities programs' initiatives primarily using research and training grants sponsored through the MURED in the Office of Equal Opportunity programs (OEOP). The research and training grants focus on specific research disciplines relevant to NASA requirements in science and technology and are used to support faculty and students at Historically Black Colleges and Universities and Other Minority Universities, thereby increasing the scientific and technological contributions from these institutions and increasing the pool of minorities in NASA-related science and engineering disciplines. In FY 1992, the NASA Program Offices (POs) became more directly involved and responsible for the selection, funding and conduct of minority university research. The Program Offices are working collaboratively with the OEOP to expand institutional research capability at minority universities and to enhance research opportunities for faculty principal investigators (PIs) and student researchers in the Program Offices areas of responsibilities. Ultimately, it is anticipated that the institutions, faculty, and students will compete successfully in NASA's mainstream research and employment processes. This new process also facilitates NASA's efforts to comply with the Congressional direction that 8 percent of NASA's total procurements shall go to small, minority, and women-owned businesses including Historically Black Colleges and Universities and Minority Universities.

To encourage the development of talent at the undergraduate and graduate level, NASA will continue the Graduate Student Researchers program/underrepresented minority focus and the Undergraduate Student Researchers program/underrepresented minority focus. The Undergraduate Student Researchers program/underrepresented minority focus was introduced in FY 1991, based on the recommendations of NASA PIs. The concept also is in consonance with the recommendations of the National Task Force on Women, Minorities, and the Handicapped in Science and Technology, which urged the establishment of a variety of scholarships, fellowships, hands-on research experience and other support to capture and develop these groups. It has become increasingly apparent that many promising minority high school graduates with excellent grade point averages and SAT scores enter college, but do not elect science and engineering fields. Further, many of the minority science and engineering students who succeed at the undergraduate level and who have the ability to do graduate level research, never consider research as a career option. Through the Undergraduate student researchers program/underrepresented minority focus, NASA PIs involve minority students pursuing masters and Ph.D. degrees in areas of interest to NASA in NASA-sponsored research projects. The objective of both these programs is to build a pipeline of talented underrepresented minority students to ensure increased numbers for graduate studies.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Historically black colleges and universities (HBCU).....	11,000	11,400	11,400	12,200

OBJECTIVES AND STATUS

The objectives of the Historically Black Colleges and Universities program are to continue to increase the level of NASA's participation with Historically Black Colleges and Universities and to strengthen the infrastructure of selected universities. Special emphasis will be placed on enhancing the math and science abilities of students at these universities, which will lead to careers in science and engineering research. Demographic changes forecast for the United States make it mandatory for NASA to increase the science and engineering pipeline of students available in order to sustain technical workforce requirements through the 21st century.

During FY 1991, seven Historically Black Colleges and Universities Research Centers were competitively selected in science and technology disciplines related to NASA research requirements. These Historically Black Colleges and Universities Research Centers received initial funding in FY 1992 and have begun regular meetings with the NASA Field Installations and Headquarters program offices to implement focused research activities leading to "mainstream" capability at the Historically Black Colleges and Universities. Research center activities include PIs, undergraduate students and graduate students. Collaborative efforts between the Minority University Research and Education Programs Division and the NASA technical offices will provide long-term guidance for the Historically Black Colleges and Universities Research Centers with funding and technical oversight. In FY 1994, the Historically Black Colleges and Universities Research Centers will be primarily funded by the Office of Space Flight (OSF), the Office of Space Science (OSS), Office of Mission to Planet Earth (OMTPE), and the Office of Aeronautics (OA).

Funding for individual unsolicited PI proposals will continue and grants will be awarded for research and for training to bring new talented faculty members into the research arena on a regular basis. New science and engineering grants will provide for a broader range of space science and technology efforts at Historically Black Colleges and Universities, with emphasis on nurturing new technologies for OSS, OMTPE, OA and other NASA technical offices.

All ongoing and new Historically Black Colleges and Universities research activities will be funded by the program offices referenced above and the Office of Minority University Research. This continued collaboration will accelerate the developmental process at the Historically Black Colleges and Universities institutions and facilitate their contributions to NASA's research efforts.

BASIS OF FY 1994 ESTIMATE

Funding will be used to support the seven Histcrically Black Colleges and Universities Reaearch Centers, provide support for individual Principal Investigator grants, and to continue award of trsining grants. Funding from the program offices will complement funds from OEOP to continue Historically Black Colleges and Universities research efforts.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Other minority universities (OMU).....	4,700	4,800	4,800	4,532

OBJECTIVES AND STATUS

The objectives of the Other Minority Universities program are to continue to work in collaboration with NASA Program Offices and Field Installations to implement a comprehensive program that provides opportunities for universities with significant minority enrollments to compete for individual PI awards, institutional research awards, and educational and training awards. These awards will enhance the retention and advancement of minority and disabled secondary students in mathematics-based curricula, expand science and math enrichment opportunities for in-service teachers, and increase cultural diversity among pre-service mathematics and science teachers at schools with significant minority enrollments.

In FY 1993, the Office of Space Science and the Office of Aeronautics (OA) continue to provide the majority of funding for NASA research conducted at Other Minority Universities s while OEOP funds all the educational and training programs at these institutions. Additionally, OSS and the OA worked with OEOP to implement and jointly fund a new research program entitled the Faculty Awards for Research (FAR) Underrepresented Minority Focus program in FY 1992. The goal of the FAR program is to achieve NASA's mission while enhancing cultural diversity in the NASA-sponsored research community. Since implementing the FAR program, twenty-four outstanding and promising faculty researchers have been competitively selected to conduct research in NASA-related fields of space and Earth sciences, and aerospace technology. Each FAR recipient has been assigned a technical monitor at a NASA Installation or at the Jet Propulsion Laboratory. Each FAR award provides support of the planned research activities for up to three years based on the annual determination of continuing achievement and subject to the availability of funds.

BASIS OF FY 1994 ESTIMATE

In FY 1994, NASA will continue to fund comprehensive educational and training programs at Other Minority Universities s and will jointly fund with NASA Program Offices, research conducted at universities with significant minority enrollments including the FAR and Institutional Research Awards for Minority Universities (IRAMUs). It is expected that ten additional FAR and several IRAMUs will be made during this period. It is anticipated that the IRAMUs will be awarded for a five year period starting with a funding level of $200,000 per year, increasing up to an annual funding level of $500,000. These awards will provide for research and supporting equipment and faculty development in areas relevant to NASA's mission. Additionally, OEOP will competitively select Other Minority Universities to receive Math and Science Awards for Teacher and Curriculum Enhancement programs (MSATCE). It is expected that awards for the MSATCE program will be for four years with a maximum funding level of $150,000 annually.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Graduate student researchers program (underrepresented minority focus) (GSRP/UMF).....	3.300	3.400	3.400	3.368

OBJECTIVES AND STATUS

The objectives of the Graduate Student Researchers program/underrepresented minority focus programs are to enhsnce the development of underrepresented minority talent in an effective wsy so as to utilize the potential of this Nation's diverse citizenry; and to increase the size of the resource pool of research skills that will be needed to meet aerospace and other technological objectives of the future. Principal investigators who have NASA research grants and a need for further student involvement will be encouraged to seek out talented underrepresented minority students snd involve them in their NASA research projects. The underrepresented minorities who are the special focus of this program include African-Americans, Hispanics, American Indians and Pacific Islanders. They must be enrolled in masters or doctoral programa in engineering, physics, mathematics, computer science, biology, or other disciplines of interest to NASA. Data show that approximately 60 percent of the Graduate Student Researchers program/underrepresented minority focus students are in Ph.D. programs, and that Africsn-Americans and Hispanics mske up about 90 percent of the program population. This is particularly encouraging since recent national scientific manpower data show African-Americans and Hispanics making the least educational advancement of all target groups in science and engineering.

In FY 1992, the sixth year of the program, an additional 53 underrepresented minority students were selected for a total of 118 participants in the progrsm. This total included 38 African-Americans males, 12 African-Americans females, 50 Hispanic males, 7 Hispanic females, 3 American Indisn malea, 1 American Indian female, 3 Pacific Islander males and 3 Pacific Islander females and 1 disabled msle. FY 1993 shows a continuing upward trend in applications and candidates.

BASIS OF FY 1994 ESTIMATE

Funding in FY 1994 will support an additional 70 students in this program. This increase is attributable to the tremendoua growth in interest and competitiveness within the program.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Undergraduate student researchers program (USRP) (underrepresented minority focus)...	3,000	3,100	3,100	3,100

OBJECTIVES AND STATUS

This program, begun in FY 1991, identifies high ability high school senior and continuing first year underrepresented minority students majoring in science or engineering and awards them portable scholarships through universities with proven records of recruiting, retaining, and graduating minority science and engineering students. This program will grow by approximately 75 students each year, so that by the 4th year NASA expects to be supporting approximately 300 students through the program. Our projected graduation rate is 85-90 percent, based on the fact that to date only 3 percent of the original class has dropped out of the program. The students receive tuition support; are monitored, tutored and nurtured; and spend their summers conducting research with principal investigators at their universities, NASA Installations, federal laboratories or private industry. The pipeline of undergraduate minority students majoring in the physical and life sciences and engineering coming from this program is expected to substantially and positively impact NASA's hiring needs. Even more important, these students are being targeted for graduate level studies and research careers in the fields of science and engineering. The Graduate Student Researchers program/underrepresented minority focus may serve as a feeder to the Undergraduate Student Researchers program/underrepresented minority focus. FY 1993 saw a major growth in the program, as it expanded to 225 students representing scientific and technical disciplines related to NASA's workforce needs projected over the next ten years.

In FY 1992, the second year of the program, an additional 80 underrepresented minority students were selected for a total of 154 participating in the program. This total included 78 African-Americans, 58 Hispanics, 10 Native Americans, 2 Pacific Islanders, and 6 students with disabilities.

BASIS OF FY 1994 ESTIMATE

The funding level of the Undergraduate Student Researchers program/underrepresented minority focus will approximate the funding level of the Graduate Student Researchers program/underrepresented minority focus. Since the undergraduate component will serve as a feeder to the graduate component, the proposed budget structure for the undergraduate component represents a natural progression. NASA's goal is to have a continuous flow of minority undergraduate and graduate level students in science and engineering educational tracks.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1994 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE COMMUNICATIONS — ADVANCED SYSTEMS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Advanced systems.....	22,000	23,200	23,273	24,600
Distribution by Program Amount by Installation				
Goddard Space Flight Center.....	6,100	6,200	6,373	6,400
Jet Propulsion Laboratory.....	15,400	16,500	16,400	17,600
Headquarters.....	500	500	500	600
Total.....	22,000	23,200	23,273	24,600

OBJECTIVES AND STATUS

The objective of the Advanced System program is to improve the performance, capability and reliability of future space missions in the critical areas of communications, navigation, and mission operations. This is accomplished in the program by evaluating and developing new technologies to demonstrate their feasibility to a level that allows field implementation to be undertaken with confidence. The research and development under this program has, over the years, enabled the cost-effective introduction of new technology and techniques into the Deep Space Network, the Space Network, and Communications and Data Systems. The Advanced Systems program is critical to maintain and improve our capabilities in the future.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The increase of $0.073 million is the result of transferring funds from the Research Operations Support (ROS) account.

BASIS OF FY 1994 ESTIMATE

Advances in tracking and navigation are essential for highly accurate science and communicationa missions such as Galileo, Mars Observer, Pluto-Flyby, TOPEX-Poseidon, and the Tracking Data Relay Satellite. Activities in FY 1994 will include research to provide position determination of Earth-orbiting spacecraft into an accuracy of a few centimeters and determinations, from Earth, of the angular direction of interplanetary spacecraft to a few nano-radians.

For communication between spacecraft and the ground, technology will be developed to improve existing radio frequency capabilities and enable new microwave and optical systems for future use. Developmenta in this area will include transmitters, receivers, multi-frequency feeds and reflectora in the S, X, Ku, and Ka banda of the radio spectrum (2, 8, 12, and 32 GHz). Optical communications systems for future use will be studied, concepts developed, analyzed and compared to microwave systems for cost and performance.

Future missions will have high resolution multi-spectral sensors and payloads operating at very high data rates and data volumes. Data handling technology will be developed to process, store and transmit at the high rates and volumes required by such miasiona. Another part of the effort is concerned with technology to increase the capability and efficiency of mission operationa. This involves the increased use of automation, and development and application of knowledge-based techniques; including expert syatems, artificial intelligence and improved graphics for easier human-machine interaction. Commercial open system standards will be emphasized to minimize development and cost.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS

FISCAL YEAR 1994 ESTIMATES

GENERAL STATEMENT

The objective of the National Aeronautics and Space Administration program of Space Flight, Control and Data Communications is to provide for the operational activities of the space transportation system and the tracking and communication system support to all NASA flight projects. This objective is achieved through the following elements:

SHUTTLE PRODUCTION AND OPERATION CAPABILITY: A program to provide a fully capable fleet of Space Shuttle orbiters, main engines, launch site and mission operations control requirements, spares inventory, production tooling, and other investments needed to maintain the long-term viability of the Shuttle program.

SHUTTLE OPERATIONS: A program to provide the standard operational support services for the Space Shuttle. Within Shuttle operations, external tank and solid rocket booster flight hardware is produced; operational spare hardware is provisioned, overhauled and repaired; and manpower, propellants, and other materials are furnished to conduct both flight and ground (launch and landing) operations.

LAUNCH SERVICES: A program to provide for procurement of expendable launch vehicle services.

SPACE AND GROUND NETWORKS, COMMUNICATIONS AND DATA SYSTEMS: A program to provide vital tracking, telemetry, command, and data acquisition support to meet the requirements of all NASA flight projects using ground-based and satellite (Tracking and Data Relay Satellite System) components.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS

FISCAL YEAR 1994 ESTIMATES

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
SHUTTLE PRODUCTION AND OPERATIONAL CAPABILITY	1,296.4	1,012.8	1,053.0	1,189.6
SHUTTLE OPERATIONS	3,029.3	3,115.2	3,016.0	3,006.5
LAUNCH SERVICES	155.8	217.5	180.8	300.3
SPACE AND GROUND NETWORKS, COMMUNICATIONS AND DATA SYSTEMS	903.3	921.0	836.2	820.5
TOTAL	5,384.8	5,266.5	5,086.0	5,316.9

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PROPOSED APPROPRIATION LANGUAGE

Space Flight, Control and Data Communications

For necessary expenses, not otherwise provided for, in support of space flight, spacecraft control and communications activities of the National Aeronautics and Space Administration, including operations, production, services, minor construction, maintenance, repair, rehabilitation, and modification of real and personal property; tracking and data relay satellite services as authorized by law; purchase, lease, charter, maintenance and operation of mission and administrative aircraft; [$5,086,000,000] *$5,316,900,000*, to remain available until September 30, [1994] *1995*. *(Departments of Veterans Affairs and Housing and Urban Development, and Independent Agencies Appropriations Act, 1993.)*

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS

REIMBURSABLE SUMMARY
(In thousands of dollars)

	Budget Plan		
	1992	1993	1994
Shuttle production and operational capability	67,043	22,914	16,375
Shuttle operations	110,713	51,464	60,750
Launch services	81,034	90,195	87,300
Space and ground networks, communications and data systems	60,288	91,823	95,000
Total	319,078	256,396	259,425

NATIONAL AERONAUTICS AND SPACE ADMINSTRATION

FISCAL YEAR 1994 ESTIMATES

DISTRUBTION OF SPACE FLIGHT CONTROL AND DATA COMMUNICATIONS BUDGET PLAN BY INSTALLATION AND FISCAL YEAR

(Thousands of Dollars)

Program		Total	Johnson Space Center	Kennedy Space Center	Marshall Space Flight Center	Stennis Space Center	Goddard Space Flt Center	Jet Propulsion Lab	Ames Research Center	Langley Research Center	Lewis Research Center	NASA HQ
Space Transportation Sys	1992	4,325,700	1,279,900	1,073,000	1,837,100	41,200	0	0	5,900	200	600	87,800
	1993	4,068,969	1,248,100	1,078,800	1,572,800	37,600	0	0	6,700	0	0	124,969
	1994	4,196,100	1,311,500	1,066,900	1,728,400	41,900	0	0	6,300	0	0	41,100
Shuttle Production	1992	1,296,400	413,200	125,900	713,300	28,800	---	---	---	200	600	14,400
	1993	1,053,016	383,600	96,300	507,100	24,100	---	---	---	---	---	41,916
	1994	1,189,600	414,300	88,600	639,600	28,500	---	---	---	---	---	18,600
Shuttle Operations	1992	3,029,300	866,700	947,100	1,123,800	12,400	---	---	5,900	---	---	73,400
	1993	3,015,953	864,500	982,500	1,065,700	13,500	---	---	6,700	---	---	83,053
	1994	3,006,500	897,200	978,300	1,088,800	13,400	---	---	6,300	---	---	22,500
Launch Services	1992	155,800	---	8,000	---	---	83,900	---	---	---	63,900	---
	1993	180,801	---	9,600	47,301	---	77,600	---	---	---	46,300	---
	1994	300,300	---	10,300	51,100	---	93,400	---	---	---	145,500	---
Space & Ground Networks,	1992	903,275	21	700	56,300	---	581,823	177,739	13,000	1	200	73,491
Communciations, & Data	1993	836,230	200	---	58,200	---	532,521	187,400	15,663	---	200	42,046
Systems	1994	820,500	---	---	59,620	---	516,780	185,800	17,700	---	200	40,400
TOTAL BUDGET PLAN	1992	5,384,775	1,279,921	1,081,700	1,893,400	41,200	665,723	177,739	18,900	201	64,700	161,291
	1993	5,086,000	1,248,300	1,088,400	1,678,301	37,600	610,121	187,400	22,363	0	46,500	167,015
	1994	5,316,900	1,311,500	1,077,200	1,839,120	41,900	610,180	185,800	24,000	0	145,700	81,500

SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS

FISCAL YEAR 1994 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE FLIGHT

SPACE SHUTTLE PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate	Page Number
		(Thousands of Dollars)			
Shuttle production and operational capability	1,296,400	1,012,800	1,053,016	1,189,600	SF 1-1
Shuttle operations	3,029,300	3,115,200	3,015,953	3,006,500	SF 2-1
Total	4,325,700	4,128,000	4,068,969	4,196,100	
Distribution of Program Amount By Installation					
Johnson Space Center	1,279,900	1,324,700	1,248,100	1,311,500	
Kennedy Space Center	1,073,000	1,056,700	1,078,800	1,066,900	
Marshall Space Flight Center	1,837,100	1,573,000	1,572,800	1,728,400	
Stennis Space Center	41,200	30,600	37,600	41,900	
Langley Research Center	200	--	--	--	
Lewis Research Center	600	--	--	--	
Ames Research Center	5,900	5,800	6,700	6,300	
Headquarters	87,800	137,200	124,969	41,100	
Total	4,325,700	4,128,000	4,068,969	4,196,100	

OFFICE OF SPACE FLIGHT

SPACE SHUTTLE PROGRAM

OBJECTIVES AND JUSTIFICATION

The primary program objective of the Space Shuttle is to continue supporting NASA launch requirements while maintaining the program focus on safety and mission success demonstrated since returning the Shuttle to flight. The Shuttle is a key element of America's space program because of its unique capabilities. The Shuttle is the first reusable space vehicle and is configured to carry many different types of space apparatus, spacecraft and scientific experiments. In addition to transporting materials, equipment and spacecraft to orbit, the Shuttle offers unique capabilities such as: retrieving payloads from orbit for reuse; servicing and repairing satellites in space; safely transporting humans to and from space; operating and returning space laboratories.

The Shuttle program strategic thrust is to maintain the capability to fly eight flights per year. In addition, the program is currently implementing modifications that will improve the safety margins of the Shuttle by a factor of two as well as providing performance and capability enhancements such as a 30-day Extended Duration Orbiter (EDO) capability. However, the program is acutely aware that providing reliable access to space must be cost-effective if we expect to exploit our capability. As a result, major cost reductions have been implemented since the FY 1992 Congressional budget.

The Shuttle is funded under two budget line items: Shuttle Production and Operational Capability and Shuttle Operations. Shuttle Production and Operational Capability provides for continued modification and improvement to the flight elements and ground facilities. This investment is necessary to enhance Shuttle capabilities, sustain the flight rate, and expand safety and operating margins. This line item contains the following major subdivisions: Orbiter Operational Capability, Propulsion Systems, the Advanced Solid Rocket Motor (ASRM), Launch and Mission Support, and Safety and Obsolescence Upgrades, previously designated Assured Shuttle Availability (ASA). The Shuttle Operations budget provides for the launch of NASA missions, as well as missions for certain commercial and international users on a reimbursable basis. Within Shuttle Operations, funding is provided in four areas: flight operations, flight hardware, launch and landing operations, and research operations support. The Shuttle launch schedule calls for a maximum flight rate of eight per year in FY 1993 through FY 1995. The Operations budget is also the major source of efficiencies that have served to significantly reduce the cost of flying the Shuttle. When measured from the FY 1992 President's budget baseline for FY 1993 and FY 1994, over 20 percent reduction will be realized although a small portion is due to changes in the planned flight rate.

The FY 1994 Space Flight budget reflects the study of incorporating Russian space technology into planned NASA activities. At the June 1992 summit meeting in Washington, President Bush and Russian President Yeltsin discussed a series of space initiatives their two countries would pursue based on a Joint Statement of Cooperation in Space signed on June 17, 1992. In July 1992, the NASA Administrator signed a Memorandum of Discussion with the General Director of the Russian Space Agency which outlined a cooperative Human Space Flight program. The program involves flying a Russian cosmonaut aboard a Shuttle flight later this year and an astronaut will fly to the Mir on a Soyuz spacecraft in 1995. Later in 1995, the orbiter Atlantis will dock with the Mir and life science experiments will be conducted. The NASA astronaut and the two cosmonauts who have been on Mir will be returned on the Shuttle to the United States for continued post-flight life science studies. The necessary modifications to the orbiter along with purchase of the Russian docking mechanism is included in this budget. Two other possible areas of technology sharing are the use of the Soyuz-TM spacecraft as an interim rescue vehicle for Space Station and the use of Russian hardware for Automated Rendezvous and Capture (AR&C) to support potential unmanned resupply to the Space Station.

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BASIS OF FY 1994 FUNDING REQUIREMENT

SHUTTLE PRODUCTION AND OPERATIONAL CAPABILITY

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate	Page Number
		(Thousands of Dollars)			
Orbiter operational capability.....	278,600	305,500	297,016	297,200	SF 1-4
Propulsion systems.....	357,000	357,700	293,400	297,900	SF 1-7
Advanced solid rocket motor (ASRM).....	315,000	--	195,000	280,400	SF 1-10
Launch and mission support.....	241,200	210,700	178,100	173,900	SF 1-12
Safety and obsolescence upgrade.....	104,600	138,900	89,500	140,200	SF 1-14
Total.....	1,296,400	1,012,800	1,053,016	1,189,600	
Distribution of Program Amount by Installation					
Johnson Space Center.....	413,200	420,200	383,600	414,300	
Kennedy Space Center.....	125,900	110,000	96,300	88,600	
Marshall Space Flight Center.....	713,300	422,100	507,100	639,600	
Stennis Space Center.....	28,800	18,000	24,100	28,500	
Langley Research Center.....	200	--	--	--	
Lewis Research Center.....	600	--	--	--	
Headquarters.....	14,400	42,500	41,916	18,600	
Total.....	1,296,400	1,012,800	1,053,016	1,189,600	

OBJECTIVES AND STATUS

Shuttle Production and Operational Capability provides for development activities to improve Shuttle safety margins, ensure the continual availability of existing capabilities, and a limited expansion of Shuttle capabilities when required by specific customer flight requirements. Included in this budget line are: orbiter design modifications and improvements necessary to support the Space Shuttle; continued development and testing of propulsion systems; continuation of the Advanced Solid Rocket Motor (ASRM) development; capabilities at the launch site and mission control center to support the launch and flight operations process; and development of safety improvements as well as replacement of obsolete systems to ensure the long term viability of the Shuttle program.

Orbiter Operational Capability provides for necessary improvements, modification kits, and mission kits that enable the orbiter fleet to satisfy flight requirements. Although the production of additional orbiters is not planned, the production of high-risk spares like aero surfaces and doors will continue. The Extended Duration Orbiter (EDO) development is funded to increase the on-orbit duration from the baseline 7-10 days, enabling the Shuttle to support an increased variety of payload requirements. Two new items are now included in this budget line and they are: (1) support for an FY 1995 docking with the Russian Mir Space Station and, (2) an expansion of the EDO to support missions of up to 30 days.

Propulsion systems funds the production, continued development, and extensive testing of the Space Shuttle Main Engine (SSME) and the development of capability enhancements to support Solid Rocket Booster (SRB) operational requirements. The SSME program is focused on improving operating margins by introducing safety, life extension, and producibility enhancements. Funding in this line pays for spare hardware, personnel, and other support needed to develop and test these enhancements. The SSME production program also buys new, replacement engines to support the flight and ground test program. The SRB production and capability development activities include static test firing of redesigned solid rocket motors to certify new subsystem developments for flight, to obtain engineering data on motor performance, and to reclaim reusable hardware needed for the flight program. Development of an asbestos-free insulation for the solid rocket motor is also included. Propulsion activities also cover modifications to booster hardware and ground support equipment.

The ASRM project is designed to improve flight safety, reliability, producibility, and performance of the Space Shuttle's Solid Rocket Motor through new design, materials and manufacturing processes. Flight safety and reliability will be improved by reducing failure modes. Producibility will be enhanced through new, highly automated facilities that will use the most efficient production tools in the solid rocket motor industry. The ASRM increase in Shuttle payload lift capability of 12,000 pounds will be achieved through a more energetic propellant, improved design configuration, and reduced inert weight. The impact to other Space Shuttle elements will be limited without compromise to flight safety and reliability. The ASRM program has recently undergone a restructure in response to the FY 1993 appropriated funding levels and the FY 1994 budget request and is now scheduled to support a first flight at the end of calendar year 2000.

Launch and Mission Support funds investment in ground facilities at both the launch site and mission control so that the planned flight rate can be safely maintained. At the Kennedy Space Center (KSC), these investments are required to replace obsolete systems or to improve process efficiency. At the Johnson Space Center (JSC), mission support provides for improvements in the flight support systems such as Shuttle training and carrier aircraft, the Mission Control Center (MCC), the Shuttle Mission Simulator (SMS), and the Flight Analysis and Design System (FADS).

Previously titled Assured Shuttle Availability (ASA), the Safety and Obsolescence Upgrade program provides improvements to the flight hardware and ground systems required to maintain the long-term viability of the Shuttle program. This change reflects a new, major objective in the Shuttle program to dramatically improve safety margins. Desired safety improvements in support of this objective will be designed, developed and implemented in this budget. In the past, these types of activities would have become reliability concerns and would have been funded by individual projects as requirements evolved. An aggressive program to replace obsolete flight hardware and ground systems is mandatory as the Shuttle ages if we are to realize the full investment in the program. To ensure that the highest priority requirements for the program are supported in a timely and cost-effective manner, individual projects are funded based on a program-wide vulnerability assessment.

CHANGES FROM FY 1993 BUDGET ESTIMATE

Overall, Shuttle Production has increased $40.2 million in FY 1993. This is the result of the addition of the ASRM by Congress in FY 1993 at a funding level of $195 million. Partially offsetting this increase are decreases in orbiter operational capability, propulsion systems, launch and mission support, and safety and obsolescence upgrades. To accommodate a general reduction directed by Congress in FY 1993, allowances for potential changes were constrained to an absolute minimum in orbiter and propulsion systems. Other decreases include: (1) reduced testing on the main engines, (2) reductions in the structural spares program, (3) reassessments of equipment upgrades at KSC and JSC, and (4) reductions in the safety and obsolescence upgrades due to the deferral of implementation of the LOX pump as well as reducing new studies and candidates.

BASIS OF FY 1994 FUNDING REQUIREMENT

ORBITER OPERATIONAL CAPABILITY

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Orbiter	158,800	196,900	179,516	127,100
Mir support	30,500	--	37,500	53,000
Extended duration orbiter (EDO)	10,700	21,700	22,600	67,700
Structural spares	57,600	51,000	35,000	35,000
Systems integration	7,200	26,900	13,400	14,400
Orbiter spares	13,800	9,000	9,000	--
Total	278,600	305,500	297,016	297,200

OBJECTIVES AND STATUS

Orbiter production activities include safety modifications, capability improvements, and the development and installation of necessary hardware, software, and procedural modifications for the orbiters, the Remote Manipulator System (RMS), and the Extra-Vehicular Activity (EVA) capabilities. Work continues on improvements to achieve greater operational capabilities, reduce operational costs, and meet system requirements. In addition, there are system level engineering analysis tasks to expand safety margins and performance capabilities.

Funding is provided for Atlantis (OV-104) to dock with the Russian Mir Space Station in June 1995. The objectives of this mission are to: (1) demonstrate the docking concept with the Shuttle before potential use on the Space Station, (2) examine the potential use of the Russian docking mechanism for Station, (3) enhance our understanding of long duration operations, and (4) obtain life science benefits from long-duration research. To achieve these objectives, the flight will be a Spacelab long module mission with life science experiments. In addition, this mission will deliver two Russian cosmonauts and return to Earth three Mir crew members who will be subjected to extensive post-flight research while they recover from the mission. Funding for the Spacelab portion of this mission is included under the Spacelab budget, while the science costs are part of the Space Science budget. Funding under this budget line purchases the Russian docking mechanism through a Rockwell contract with NPO Energia. The costs for Rockwell to modify the mechanism and to integrate it with the orbiter are also included.

The Extended Duration Orbiter (EDO) program provides for the necessary capabilities to extend the on-orbit duration from the baseline of 7-10 days. The first phase provides a cryogenic pallet system to support Spacelab-type flights for periods up to 16 days. The initial pallet development was financed by Rockwell, and funding is provided as part of the commercialization agreement. Logistics items affected by extended on-orbit operations such as repair parts for fuel cells are also included. Columbia is the initial EDO vehicle and the first flight utilizing the pallet was in June 1992 on the United States Microgravity Laboratory (USML-1) mission. The first 16-day mission is planned on USML-2 in FY 1995. Beginning in 1994, NASA plans to initiate an expansion of the EDO program. The objective is to support flights of up to 30 days. The benefits of the program are: (1) to allow the capability of obtaining long-duration life acience studies extending human presence in space and, (2) extending crew interaction with basic life sciences and materials research. The plan is to procure a second pallet system and to modify Endeavour and Atlantis with an enhanced autoland capability (auto braking, nose wheel steering upgrades, and a disengage switch) along with various other upgrades to support these longer stay times. The necessary upgrades to utilize Spacelab for these missions are included in the Spacelab budget.

The structural spares program has been rebaselined to focus on high-risk spares such as payload bay doors, elevons, body flaps, and other items susceptible to damage. The production of major structures such as the aft fuselage and the mid-body are no longer planned. However, this rebaselined program, together with other tasks at the prime contractor facilities (e.g. - Mir, EDO, the Orbiter Maintenance Down Period (OMDP) on OV-104 performed at Palmdale this year, etc.), should retain some manufacturing skills.

Systems integration tasks include the continuing development of the Program Compliance and Assurance System (PCAS) which is a comprehensive Shuttle data base that examines failure histories across all the Shuttle elements. Also included are contingency landing and abort analyses to support full utilization of existing orbiter capabilities.

Orbiter spares comprises certification of the NASA Shuttle Logistics Depot (NSLD) to repair hardware previously serviced by Original Equipment Manufacturers (OEMs). Standard and automated test equipment, maintenance manuals and other items are covered. This activity is being concluded this year.

CHANGES FROM FY 1993 BUDGET ESTIMATE

Overall, Orbiter Operational Capability decreased $8.5 million in FY 1993. To partially accommodate a general reduction of $60 million to Shuttle Production and Operational Capability directed by Congress, funding for unanticipated program changes was reduced $50.8 million. This reduction was partially offset by increased requirements to conduct the OMDP on OV-104 at Palmdale instead of at the launch site as well as $37.5 million to fund requirements to support the Mir mission. A reduction in the structural spares program was also made in response to Congressional action and this program was subsequently rebaselined.

BASIS OF FY 1994 ESTIMATE

Orbiter operational capability supports the development and implementation of improvements to the orbiter fleet for the enhancement of safety, operations, performance, and economy. Tasks to be continued in FY 1994 include improvements to Auxiliary Power Unit components such as the Gas Generator Valve Module (GGVM); continuing analysis of the external tank debris experienced during separation; upgrades to the Remote Manipulator System (RMS) servo-power amplifier to accommodate heavier loads; upgrades to the rate gyro assembly which is also used in the Solid Rocket Booster (SRB); and various orbiter support tasks such as Orbiter Manuevering System/Reaction Control System (OMS/RCS) testing at White Sands, modifications to the RMS, and support to the Crew Escape System.

In order to support an FY 1995 mission to Mir, activity in FY 1994 will include completion of the development and qualification testing on the Russian docking mechanism by Rockwell as well as initial work on integrating this hardware into the cargo bay. The integration includes incorporation of an external airlock, being developed under the Payload Operations budget, along with a transfer tunnel to accomplish docking. During the OMDP on Atlantis at Palmdale in FY 1993, an EDO kit (minus a cryo pallet) will be installed and used on the Mir mission. Atlantis will be retained at Palmdale until mid-FY 1994 to install 30 day extended duration orbiter (EDO) capability.

EDO funding covers the payback costs to the prime contractor for use of the cryogenic pallet kit to extend on-orbit stay time capability from the baseline 7-10 days to 14-16 days. The pallet development and production were undertaken through a private financing agreement between NASA and Rockwell International. The agreement provides for recovery of investment with pallet use. Funding in FY 1994 initiates the required modifications on Endeavour and Atlantis which will be the 30-day EDO vehicles. Modifications to be included are redundant heaters, upgrades to the communications, and some hydraulic subsystem upgrades. In addition, development of a new long-life fuel cell will be started in FY 1994. Not only is a longer life fuel cell a key factor to ensure extended on-orbit operations, but it also lessens the frequency of changeouts and lowers overall maintenance, particularly if an external airlock is ultimately used. Ultimately, between what is funded in this program and in Payload Operations in the R&D appropriation, there will be three orbiters with pallet interface capability (i.e.- OV-102, OV-105, and OV-104), two external airlocks, two cryogenic pallets, 2 LDO kits, and a docking mechanism system.

For the structural spares program in FY 1994, work will continue on the vertical tail, the elevons, main landing gear doors, payload bay doors, body flap, external tank (ET) and nose gear doors, OMS skins, and wing parts. These are hardware items with a higher risk of potential damage. The OMS skins and wing parts should be completed by the end of FY 1994.

BASIS OF FY 1994 FUNDING REQUIREMENT

PROPULSION SYSTEMS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Space shuttle main engine (SSME).....	322,100	314,600	263,200	245,400
Solid rocket booster (SRB).....	34,900	43,100	30,200	52,500
Total.....	357,000	357,700	293,400	297,900

OBJECTIVES AND STATUS

The Propulsion Systems budget provides for the production of the SSMEs and the development of the safety, reliability, and producibility enhancements needed to support operational requirements for both the SSME and the SRB.

The SSME program funds development and certification activities to improve engine operating margins, safety, reliability, and durability, as well as to make the engine easier to produce and maintain. The major improvements currently in work are the single-coil heat exchanger, the Phase II+ powerhead, the Alternate Turbopumps (both LOX and Fuel), and the Large Throat Main Combustion Chamber. These improvements will effectively double the overall Shuttle safety margins once they are completed. Although the development and implementation of the Alternate Turbopumps and Large Throat Main Combustion Chamber are funded under the Safety and Obsolescence Upgrades budget, testing for development and certification of these improvements is funded under this budget.

The current heat exchanger is the number one item on the list of SSME critical safety risks. The single-coil heat exchanger, currently in development, will substantially increase the safety of the engine. The heat exchanger, mounted in the powerhead, uses the hot, hydrogen-rich, gas (800° - 900° F) exiting the LOX turbine to convert liquid oxygen to gaseous oxygen for pressurizing the ET oxygen tank and the POGO suppression system. The current heat exchanger has a primary tube that splits into two secondary tubes at a bifurcation joint inside the powerhead. This joint is welded to the tubes in a difficult process that cannot be fully inspected once installed into the engine. There is a concern that over extended operations, the heat exchanger could develop oxygen leaks at the welds, or through the extremely thin tube walls (as little as 1/80 of an inch thick). Even a tiny leak of oxygen into the hot hydrogen gas would rapidly cause destruction of the engine. The single-coil heat exchanger has no welds exposed to the hot gas, and has tube walls about three times thicker than in the current design.

The SSME powerhead is the backbone of the engine. It connects the two preburners powering the high-pressure turbopumps with the main propellant injector through a hot-gas manifold, and contains the heat exchanger as well as the attachment points for the high-pressure turbopumps and the main combustion chamber (MCC). The current hot-gas manifold links the main injector to the fuel preburner with three ducts and to the oxidizer preburner with two ducts. This configuration yields hot gas flows with non-uniform pressures and velocities, as well as large pressure drops, conditions which place high dynamic loads on main injector elements and reduce engine performance. In addition, the significant pressure drop in hot gas flow in the ducting from the fuel turbine to the main injector places large lateral loads on the sheet metal structure in the high-pressure fuel turbopump. The current powerhead is constructed with a large number of welds, making it difficult to produce and raising concerns about quality, reliability, and long-term durability and safety. The Phase II+ powerhead addresses the issues with the current design by using a two-duct configuration between the fuel pump and the main injector to significantly improve the hot gas flow characteristics, and by reducing the number of welds by 24 percent. Testing on the Phase II+ powerhead with the single-coil heat exchanger began in 1992, with certification testing scheduled to be completed in mid-1995.

The SSME Propulsion Systems funding is provided for contractor test and engineering manpower and for hardware. The hardware procured includes spare parts for test engines, newly designed components like the two-duct hot-gas manifold and the single-coil heat exchanger, and new engines to replace those in the test fleet that reach their life limits. The SSME project support and other support, also funded in Propulsion Systems, pay for NASA supporting engineering at the Marshall Space Flight Center (MSFC), support contractor work at the Stennis Space Center (SSC), test propellants at MSFC and SSC, and special analysis and studies at the Lewis Research Center (LeRC).

Although the redesign of the SRB to resolve deficiencies in the previous design was completed in FY 1988, efforts to increase safety margins continue and are funded in the Propulsion Systems budget. Flight data will be assessed, and recovered flight hardware will be inspected, to ensure that the boosters are performing as designed. In addition, SRB project support efforts at MSFC are funded under Propulsion Systems.

CHANGES FROM FY 1993 BUDGET ESTIMATE

FY 1993 funding requirements in Propulsion was reduced $64.3 million to accommodate the general reduction directed by Congress as well as to offset increased requirements within Shuttle Production and Operational Capability. The decrease in the main engine program is attributed to a reduction in testing that lowered manpower, hardware, and propellant costs. Other decreases in the main engine funding for FY 1993 are due to reductions in allowances for change traffic as well as the availability of FY 1992 funds. SRB funding has decreased due to the deferral of the asbestos-free program on the Redesigned Solid Rocket Motor (RSRM) and a re-estimate of costs associated with the Technical Evaluation Motor (TEM) firings.

BASIS OF FY 1994 ESTIMATE

SSME funding in the FY 1994 budget supports the continued development, testing, material procurement, fabrication, and engine assembly operations necessary to support the flight and ground test programs. The SSME ground test program is based on an average test rate of eight tests per month (460 seconds duration) through FY 1994. The primary purpose of this testing is to develop and flight-certify improved hardware like the Phase II+ Powerhead (two-duct hot-gas manifold), the single-coil heat exchanger, and the Alternate Turbopump. Ground testing will also be performed on all new or recycled flight hardware prior to acceptance. Other testing will be utilized to provide hot-fire experience and increase life limits on flight-configured engines. Beginning in FY 1994, funding for the Technology Test Bed will be transferred to the Engineering and Technology Base (ETB) program. The test bed is an institutional capability allowing improvements across a wide range of programs including the SSME. With the completion of certification testing on the single-coil heat exchanger and the Phase II+ powerhead, as well as the stabilization of the engine design, the SSME program intends to close one of the three test stands (test stand B-1) now in use at the Stennis Space Center in FY 1995. The two remaining stands will be used for acceptance tests of new and recycled hardware, for flight certification of upgrades such as the Large Throat Main Combustion Chamber (LTMCC), and for tests to extend hardware life limits. New attrition engines will continue to be produced in FY 1994 to support deliveries in FY 1995 and FY 1998. The Block II controller, which was flown for the first time in FY 1992 on Endeavour's maiden voyage, is expected to complete production in 1993, with 1994 funding to be used to buy initial spare parts and test equipment. However, the other significant upgrades, such as the Phase II+ and the single-coil heat exchanger, have hardware procurements in FY 1994.

FY 1994 funding for the SRB supports continued efforts to improve the safety and producibility of the SRB, including the RSRM. Booster funding includes: a redesign of the C-Band transponders used during booster recovery; a program to increase launch safety margins by developing a design modification which will decrease stress in critical aft skirt welds; and the design of a new test set for the integrated electronics assembly. Due to the restructure of the ASRM and its associated delay into the Shuttle program, an asbestos-free RSRM will be implementated in 1997. FY 1994 RSRM funding also pays for motor ground tests and for disposal of Filament Wound Cases (FWC) produced and filled with propellant in the mid-1980s before the termination of the lightweight composite case effort. SRB project support activities at MSFC needed to support these development efforts will continue.

BASIS OF FY 1994 FUNDING REQUIREMENT

ADVANCED SOLID ROCKET MOTOR (ASRM)

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Advanced solid rocket motor (ASRM).....	315,000	--	195,000	280,400
(Included in Construction of Facilities (CofF) budget).....	(150,000)	(--)	(165,000)	(32,600)

OBJECTIVES AND STATUS

The objectives of the ASRM program are to improve the system safety and reliability of the Shuttle while increasing payload lift capability. These objectives are achieved in the following ways: (1) a better motor design that reduces hot gas leak paths by 88 percent, (2) a reduction in the number of segments from four in the RSRM to three, (3) use of welded factory joints, (4) field joints designed to close under operating pressure,(5) decreased SSME throttling requirements provide significant system enhancements and benefits particularly for engine-out scenarios, (6) a highly automated manufacturing process that minimizes variations in production and enhances quality control, and (7) using a non-asbestos insulation which eliminates the risks associated with asbestos. Payload lift capability will be increased by 12,000 pounds due to the larger diameter of the motors and the use of a higher performance propellant.

The ASRM will be manufactured in a new, environmentally friendly, advanced state-of-the-art production plant. Among the key features in the production process are a continuous mix and cast propellant process, use of robotics, automated process controls, and closed loop control of production by-products. The advanced technology should ensure the highest possible worker safety, motor reliability, and environmental protection during operations.

The ASRM design and development is well underway. Since the prime contract was signed in May 1990, a successful motor Preliminary Design Review (PDR) was held in February of last year. The facility design is essentially complete and the construction is 55 percent complete. All environmental permits are in place and plant equipment designs are essentially finished with a significant amount of equipment procurements currently being completed. All planned propellant continuous mix pilot plant tests have been successfully accomplished. Seven 48 inch subscale motors have been test fired to evaluate insulation and characterize nozzle materials. Full scale case segment articles are in various stages of completion. Case segment factory welding and heat-treat of the Transient Pressure Test Article (TPTA) is underway. The goal of achieving an additional 12,000 pounds of lift capability continues to be attainable and the ASRM is currently scheduled for a first flight before the end of calendar year 2000.

CHANGES FROM FY 1993 BUDGET ESTIMATE

Due to the tight budget environment, constrained outyear funding projections, and other factors the ASRM was not included in the FY 1993 budget request. Congress reinstated funding for the ASRM in NASA's FY 1993 appropriation. However, the funding level directed in the Conference Report (House Report #102-389) accompanying the FY 1993 VA-HUD-Independent Agencies Act (PL #102-389) was lower than that for the previous year. In addition, the program experienced some internal delays. The program was rebaselined for a later first flight date. In order to continue the program at the lower funding levels, many actions are being undertaken in FY 1993. The Thiokol contract was terminated with a proposal for specific tasks requested. Babcock and Wilcox, the supplier of the case segments, reduced its FY 1993 production while Lockheed-Austin was reduced consistent with the restructure. Other awards were also delayed such as the nozzle facility building at Michoud, the barge dock at Yellow Creek, the Rotation, Processing, and Surge Facility (RPSF) at KSC, and some test stands at MSFC.

BASIS OF FY 1994 ESTIMATE

Consistent with overall agency funding constraints, the ASRM schedule has been further adjusted to match funding availability in FY 1994 and future years. First launch of the Shuttle utilizing ASRMs is now planned at the end of calendar year 2000.

Throughout FY 1994, work will continue in the areas of facilitization and activation, process verification including soluble core, motor case manufacturing, and systems engineering. Unawarded contracts delayed from the current year will be awarded. The final assembly and mix/cast facilities will progress towards start-up milestones in 1993 and 1994, respectively. The case preparation facility will be ready for use in mid-1994. Originally, the first Developmental Motor (DM-1) static test firing was to commence at the end of 1994, but under the restructured program the DM-1 firing will not take place until mid-1998. The Transient Pressure Test Article (TPTA) and the modal survey will be slipped to the 1998 time frame. Motor manufacturing needed to support these milestones is being delayed consistent with the restructured schedule. The Critical Design Review (CDR) originally scheduled for February 1995 will be deferred until July 1998. An Interim Critical Design Review (ICDR) is scheduled in August 1995.

BASIS OF FY 1994 FUNDING REQUIREMENT

LAUNCH AND MISSION SUPPORT

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Launch site equipment (LSE).....	93,100	86,000	69,000	68,500
Mission support capability.....	148,100	124,700	109,100	105,400
Total.....	241,200	210,700	178,100	173,900

OBJECTIVES AND STATUS

This activity supports the development of launch and mission support capabilities, principally at the Kenndy Space Center (KSC) and the Johnson Space Center (JSC).

The major operational Space Shuttle facilities at KSC include three Orbiter Processing Facilities (OPFs), two launch pads, the Vehicle Assembly Building (VAB), the Launch Control Center (LCC), and three Mobile Launch Platforms (MLPs). These facilities support the prelaunch and post-landing processing of the four orbiter fleet. Key enhancements funded in Launch Site Equipment include: development and implementation of a digital operational intercom system (OIS); replacement equipment for the Launch Processing System (LPS); an improved Checkout, Control, and Monitoring System (CCMS II); a Shuttle Processing Data Management System (SPDMS); a Launch Team Training System (LTTS); fiber optic cabling; and the Launch Equipment Test Facility (LETF) support.

The mission support capability budget funds JSC projects to improve capabilities or replace obsolete equipment such as: the Mission Control Center (MCC) equipment upgrade; the flight and ground support training facility improvements; and the flight design systems enhancements. Necessary improvements are being made in simulation training in both the Shuttle Mission Simulator (SMS) and the MCC. SMS upgrades include new host computers, interface hardware and simulator subsystems. The MCC will have improved console operations and communication equipment as well as new data processing and distribution systems. Critical improvements in simulation fidelity will be accommodated with the expanded capacity of the new hardware. Reliability required for the longer integrated simulations, and associated maintenance cost, will also be substantially improved with these replacements.

Other activities funded in mission support capability include implementing required modifications and upgrades on the T-38 aircraft used for space flight readiness training, modifications needed for the replacement Shuttle Training Aircraft, capability improvements for weather prediction, and enhancements on information handling to improve system monitoring, notably for anomaly tracking.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The Launch and Mission Support total has decreased $32.6 million. Launch Site Equipment (LSE) has decreased by $17.0 million due to a reassessment of the upgrade to the CCMS-II, re-estimate of the costs to provide the LTTS and the improved SPDMS. Mission support capability has decreased $15.6 million due to a delay in modifying the Shuttle Training Aircraft replacement until 1995, a re-estimate of MCC and SMS upgrades due to rephasing and cost savings initiatives, and rephasing of the T-38 upgrades to reflect actual modification start dates.

BASIS OF FY 1994 ESTIMATE

At KSC, funding is required to continue the upgrade of the CCMS II. The CCMS-II is part of the launch processing system that performs the real-time checkout, control, and monitoring for Shuttle processing. The current system is over 20 years old and has gone without any major technology upgrades for almost 15 years. CCMS-II is currently in the post-CDR phase with deliveries to begin in FY 1994. The development should be complete by 1996 and full implementation is planned in 1998. In addition, other necessary upgrades and equipment replacements will be continued such as an orbiter ground cooling system, improved hazardous gas detection system, and improvements to the launch computer complex.

At JSC, major equipment upgrades in the MCC will continue with the replacement of aging equipment, such as the data processing and distribution system. Major subsystem upgrades in the SMS will continue with the acquisition of host and base interface computer replacements for the fixed and motion-based simulators. Associated software rehosting efforts and planning towards replacement of the instructor operator stations will take place as well. Funding supports the continuation of avionics upgrades to the fleet of T-38 aircraft as well as landing aids at the contingency/abort landing sites. In addition, the T-38s are undergoing structural and safety upgrades to prolong the aircraft service life through the auspices of the Air Force T-38 Pacer Classic program.

BASIS OF FY 1994 FUNDING REQUIREMENT

SAFETY AND OBSOLESCENCE UPGRADES

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Alternate turbopump	80,200	81,800	50,100	67,800
Multifunction electronic display system	15,100	21,900	12,000	34,400
Hardware interface module replacement	2,600	3,600	3,000	6,000
Cable plant upgrade at Kennedy Space Center	600	7,100	6,900	10,000
Large throat main combustion chamber	--	--	7,100	22,000
Studies/new candidates	6,100	24,500	10,400	--
Total	104,600	138,900	89,500	140,200

OBJECTIVES AND STATUS

In order to assure that the U.S. maintains a viable manned transportation capability into the next century, specific program investments are required. The Safety and Obsolescence Upgrades program, previously titled Assured Shuttle Availability (ASA), funds the necessary improvements on the Shuttle needed to expand existing safety margins as well as to ensure continued safe and reliable Shuttle operations by addressing obsolete systems. Improved flight turnaround times and reduced operational costs are also benefits of this program. In the past, these kinds of improvements have been added incrementally as individual items of hardware experienced problems or vendors could no longer supply older components. These types of requirements will increase as the Shuttle system ages and safer ways of operating the Space Shuttle are identified.

The management approval process utilized in the program will ensure that improvements are evaluated and approved on a priority basis across the entire Shuttle program. The orbiter vehicle, other elements of flight hardware, ground processing facilities, and other supporting systems, will all be considered in the implementation of this program.

The schedule for development and installation of orbiter-related improvementa ia designed to take advantage of the planned intervals when orbiters are scheduled to be taken out of service for atructural inspections and modifications. This plan provides for an orderly development and implementation program and minimizes interruption of the flight program. Specific, large improvements which exceed a total cost of $15.0 million will be funded from this program. Smaller improvements and modifications will continue to be funded in the individual projects.

The most challenging snd troublesome components of the Space Shuttle Main Engine (SSME) are the high pressure turbopumps. Engine system requirements result in pump discharge pressure levels between 6000 to 8000 psi and turbine inlet temperatures in excess of 2000 degrees. In reviewing the most critical items on the SSME that could lead to a catastrophic failure, 14 of the top 25 are associated with these turbopumps. Moreover, the turbopumps are difficult to manufacture and require extensive inspections and frequent removsl for overhaul and retest. Over the years, the current turbopumps have been the source of several flight delays and many ground test failures including some that were catastrophic. While remedies have been sought to address the continuing problems with the turbopumps, it was concluded in 1985 that a complete redesign was necessary. These new pumps are referred to as the Alternate Turbopumps (ATP).

The ATP incorporate state-of-the-art technology designs intended to sddress the shortcominga of the current SSME high-pressure turbopumps. The pumps use precision castings, fewer parts, atiffer ahafts, and better besrings thsn the current pumps, and the number of welds is reduced from 769 to 7. All uninspectable welds are eliminated. With these improvements, the pumps should provide increased supportability, greater safety margins, and a longer operating life than the current pumps. A number of technical problems hsve plsgued the liquid oxygen (LOX) pump, including turbine inlet cracking, turbine bellows cracking, and high synchronous vibration anomalies. Design changes have been implemented and successfully demonstrsted. The most recent technical issue, pump-end ball bearing wear, has required numerous pump rebuilds and engine testing to resolve. Testing has shown that damper seal radial support softening coupled with stiffened housings, improved coolant distribution, optimize cage designs, and potentially the uae of silicon nitride ball bearings, may have resolved this issue. One LOX pump has successfully completed aix full duration mission simulation tests, while another design has successfully completed over 2500 seconds of testing. Testing haa included nominal mission duration and power level, as well as abort duration (14 minutes) and 109 percent abort power level. Additional units will be tested in the near future, and should complete the resolution of the ball bearing anomaly. Consistent with direction contained in House Report 102-226, NASA assessed the merits of continuing development of the Alternate Fuel Pump. Development activities on the fuel pump were suspended so that effort could be focused on the more critical LOX pump. When the LOX pump ia succesafully developed, NASA will report results of the effort to Congresa and then resume development efforts on the fuel pump. Based on the current schedule, this resumption would occur in FY 1995. First flight using the LOX pump is planned for June 1995 and the first flight using the fuel pump is scheduled in FY 1998.

The Multifunctional Electronic Display System (MEDS) upgrade will allow replacement of the 1970s display technologies which are embedded in the orbiter cockpit. The current display system, which provides the pilot and commander with vehicle flight control and with the interface to the orbiter data processing system, is a single string electro-mechanical system. This system is proving to be particularly susceptible to life-related failures. The upgrade will provide both a new architecture and the flight equipment to enhance the reliability of the system and will resolve the parts availability problems. The new display system will bring the orbiter up to current aircraft standards which will have a direct benefit on training of new astronauts while also providing the potential for enhanced information flow during operations. The MEDS upgrade includes the design effort and the production of additional modification kits for the four vehicles. New ground support hardware will also be designed, procured, and installed to upgrade the appropriate simulators, test equipment, and laboratories. MEDS consists of two phases. Phase one will incorporate a multi-functional cathode ray tube display system consisting of 4 display units, 4 data processors, and 2 panel assemblies. The first flight utilizing these changes is planned in 1996. Phase two incorporates flight instrumentation and system status meters including additional panel assemblies, display driver units, and other hardware. The first flight incorporating these improvements is planned in FY 1998.

The Hardware Interface Module (HIM) cards at KSC are now obsolete and have caused an increased failure rate and repair cost over the past several years. The HIM upgrade will replace all chassis and cards with state-of-the-art "off the shelf" hardware to improve system reliability and maintainability. The design reviews were completed in FY 1992, procurement was initiated in FY 1993, and these systems should be completed by FY 1998.

The cable plant upgrade at KSC has been initiated to replace the miles of cables which support a wide variety of Shuttle facilities. Many of these cables were installed in the 1960s and are beginning to suffer increasing failure rates. Replacement will reduce the potential for disruption to critical Shuttle operations as well as have a direct maintenance benefit. This will reduce the possibility of launch delays, increase communication system spares availability, and enhance the reliability of data, instrumentation, voice, and video communications. This upgrade will replace the wideband distribution systems and the lead/antimony sheath cables installed at that time with fiber optics and plastic sheath, gel-filled cable. In addition, many field terminations will be replaced or upgraded as well as the manhole system. Other obsolete systems will also be replaced with current technology.

The SSME's staged combustion cycle and high main combustion chamber pressure (~3000 psi) result in extremely stressful internal operating conditions such as high turbine discharge pressures and temperatures, and high turbopump shaft speeds. In order to alleviate these conditions, a new project is proposed for FY 1994 entitled the Large Throat Main Combustion Chamber (LTMCC). The LTMCC differs from the current Main Combustion Chamber in several ways. The throat diameter is increased 11 percent which lowers the chamber

pressure by 9 percent. The contour of the chamber also allows an increase in the number of coolant channels, thereby reducing the operating temperature of the hot wall inside the MCC and increasing the MCC's life as well as reducing the potential for pin hole leaks and coolant channel cracks. The operating conditions discussed above are lowered by as much as 10 percent in some cases. Use of the LTMCC allows the SSME to operate at lower stress levels which directly enhances safety margins. For example, operating the LTMCC configuration at 104 percent of its Rated Power Level (RPL) is equivalent to using the current MCC at 100 percent RPL. This improvement, coupled with ongoing SSME upgrades will improve the Shuttle safety margins by a factor of two. The development program will consist of four units for testing purposes along with the purchase of the necessary units for fleet retrofit. The LTMCC program will also include the required modifications to the other elements of the SSME as well as any incremental support required by the test program. A first flight utilizing the new LTMCC is planned for FY 1998.

In FY 1993, the Safety and Obsolescence Upgrades budget also includes funding to support ongoing studies focused on the replacement of environmentally restricted materials as well as other potential items such as a simplified OMS/RCS and incorporation of the Global Positioning System (GPS) into the orbiter. None of these items will be developed until they have been fully assessed including technical approach, cost requirements, and schedule considerations.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The Safety and Obsolescence Upgrades budget has been decreased $49.4 million. Of this amount, $31.7 million is due to deferring implementation of the LOX pump on the ATP program. This delay is the result of the decision to more fully assess the outcome of the test program on the LOX pump before proceeding with its implementation. The MEDS for the orbiter cockpit has been decreased $9.9 million due to a reestimate of the phasing required to support its development. Both the HIM card replacements and the cable plant upgrade at KSC have been rephased. The LTMCC will be initiated this year in order to achieve our safety improvement goals. Funding for new studies and candidates was reduced to accommodate overall reductions in resource availability.

BASIS OF FY 1994 ESTIMATE

Alternate Turbopump (ATP) funding in FY 1994 supports development and certification testing of the high pressure liquid oxygen (LOX) pump, with certification expected to be complete by mid-1995 and first flight during that year. ATP fuel pump development funding supports continued caretaker status for an additional year. ATP implementation funding procures LOX pumps to outfit the engine fleet. However, both LOX and fuel pump production have been delayed one year from the previous budget, with the funding reduced accordingly. Initial flights of the LOX pump will use production verification pumps funded in the development effort. In FY 1994, MEDS will conduct its Critical Design Review (CDR). The MEDS prime contractor, along with the subcontractors, will also continue the building of prototype units in preparation for systems integration

testing to be started in FY 1994 and leading to the first use of this system in FY 1996. It is planned that the installation and checkout of the MEDS into the orbiter fleet will take place in such a manner that all of the four orbiters will be modified during the in-line flow process at KSC. The HIM card project will have a CDR in FY 1993 for the hardware/software integration and validation. Contracts will be awarded for the first hardware production units to be delivered in FY 1994. The KSC cable plant upgrade will involve design reviews in FY 1993 prior to replacing the cable network running from the Launch Computer Complex to the Orbiter Processing Facility, the launch pads and the vehicle assembly building. Casting development for the LTMCC will be completed by the end of FY 1994. The first LTMCC with a cast manifold should be ready for hot-fire development testing by the end of the fiscal year. This unit will be the first of four LTMCCs fabricated in FY 1994 for development and certification testing. The other three units will be delivered in FY 1995. The wedge for studies and potential new candidates has been removed to accommodate funding availability for FY 1994.

BASIS OF FY 1994 FUNDING REQUIREMENT

SPACE SHUTTLE OPERATIONS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate	Page Number
		(Thousands of Dollars)			
Flight operations	807,900	740,400	752,117	767,800	SF 2-3
Flight hardware	1,326,800	1,455,300	1,398,153	1,364,600	SF 2-5
Launch and landing operations	642,900	639,900	690,800	696,400	SF 2-7
Research operations support	251,700	279,600	174,883	177,700	SF 2-9
Total	3,029,300	3,115,200	3,015,953	3,006,500	
Distribution of Program Amount by Installation					
Johnson Space Center	866,700	904,500	864,500	897,200	
Kennedy Space Center	947,100	946,700	982,500	978,300	
Marshall Space Flight Center	1,123,800	1,150,900	1,065,700	1,088,800	
Stennis Space Center	12,400	12,600	13,500	13,400	
Ames Research Center	5,900	5,800	6,700	6,300	
Headquarters	73,400	94,700	83,053	22,500	
Total	3,029,300	3,115,200	3,015,953	3,006,500	

OBJECTIVES AND STATUS

Space Shuttle Operations provides launch services to NASA payloads as well as to other civil agencies and certain commercial and international users, on a reimbursable basis. The Shuttle operations budget is based on a planned rate of eight flights per year.

The Space Shuttle has demonstrated a broad range of capabilities including deployment of spacecraft and their upper stages, satellite repairs, satellite retrieval, operations using the remote manipulator, integral scientific experimentation using Shuttle and Spacelab systems, and extravehicular activity operations. These capabilities provide a unique national resource that enhances the scientific reward of many payloads. The major program elements of Shuttle Operations are Flight Operations, Flight Hardware, Launch and Landing Operations, and Research Operations Support.

Both the current estimate for FY 1993 and the budget estimate for FY 1994 reflect the redistribution of the Research Operations Support (ROS) funding. This restructuring charges the various NASA programs the cost of activities that directly support or benefit these programs. In Shuttle Operations, approximately $84 million worth of tasks have been reallocated to the benefitting programs.

The Space Shuttle program is aggressively continuing the major thrust initiated in FY 1992 to dramatically reduce the cost of operations. Shuttle funding in FY 1993 and FY 1994 reflects program efficiencies and content reductions of 20 percent and 22 percent respectively when measured from the baseline of the FY 1992 President's budget. Since that time, over $900 million has been removed from the Shuttle program in FY 1993 and over $1.0 billion from FY 1994. These reductions are realized after the ROS restructuring is taken into account. This represents a significant challenge for the Shuttle program, the various project offices, and the Shuttle contractors. Although the majority of these savings have been identified by specific actions, a substantial unresolved reduction remains in FY 1994. The program management is confident that the reductions can be achieved and will work aggressively towards that end.

As in the past, Shuttle Operations requirements are funded through a combination of funds received from Congressional appropriations and reimbursements received from customers manifested on the Shuttle. Planned reimbursements in FY 1993 are $45 million and in FY 1994 they are $60 million.

CHANGES FROM FY 1993 BUDGET ESTIMATE

In total, funding for Shuttle Operations has decreased $99.2 million. This net reduction is the result of a reduction in funding for Research Operations Support (ROS) of $20 million as directed by Congress, and a further reduction in content of $90 million, offset by an increase of $20 million in launch and landing operations for increased labor rate costs. The reduction of $90 million in program content is accommodated primarily by reduced funding requirements for the External Tank due to efficiencies implemented in that program, as well as reduced manpower requirements for flight integration and software activities.

BASIS OF FY 1994 FUNDING REQUIREMENT

FLIGHT OPERATIONS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Mission operations	295,900	338,400	329,117	330,900
Integration	315,400	163,000	146,000	151,700
Support	196,600	239,000	277,000	285,200
Total	807,900	740,400	752,117	767,800

OBJECTIVES AND STATUS

Flight operations is divided into three major areas of activity: mission operations, integration, and support. Mission operations includes a wide variety of preflight planning, crew training, and operations control activities. The planning activities range from the development of operational concepts and techniques to the creation of detailed systems operational procedures and checklists. Tasks include: flight planning; preparing systems and software handbooks; defining flight rules; creating detailed crew activity plans and procedures; developing and establishing the Mission Control Center (MCC) and network system requirements for each flight; and contributing to planning for the selection and operation of Shuttle payloads. Flight planning encompasses flight design, flight analysis, and software activities. Both conceptual and operational flight profiles are designed for each flight and the designers also help to develop crew training simulations and flight techniques. In addition, the flight designers must develop unique, flight-dependent data for each mission. The data is stored in the erasable memories located in the orbiter, Shuttle mission simulator, and MCC computer systems. Mission Operations funding also provides for the maintenance and operation of critical mission support facilities including the MCC, flight simulators, crew training, and flight software support facilities. Finally, beginning in FY 1993 mission operations includes maintenance and operations of aircraft needed for flight training and crew proficiency requirements. Previously, aircraft operations had been funded under support.

Integration includes payload integration into the Shuttle and system integration of the flight hardware elements. Payload integration covers the engineering analysis needed to ensure that various payloads can be assembled and integrated to form a viable cargo for each Shuttle mission. Systems integration covers the necessary engineering tasks to ensure that the system can be safely launched. Prior to FY 1993, orbiter

sustaining engineering had been funded under the integration budget. Beginning in FY 1993, this activity was placed under orbiter flight hardware to make it consistent with the other flight hardware elements which include their sustaining engineering. In addition, flight software development was transferred from Integration to Support beginning in FY 1993 so that the Integration budget captures only those elements managed by the Space Shuttle Program Office.

Support covers the engineering tasks at the Johnson Space Center (JSC) that support the Shuttle and now includes flight software development and verification. The software activities include development, formulation, and verification of the guidance, targeting, and navigation systems software in the orbiter. Support also includes the Shuttle share of the multi-program support at the manned centers.

CHANGES FROM FY 1993 BUDGET ESTIMATE

FY 1993 funding for the Flight Operations budget increased by $11.7 million. An additional $43.3 million was added to Flight Operations due to a transfer from the Research and Operations (ROS) budget. This transfer is based on restructuring ROS to fund administrative operations at the Centers and to align appropriate cost to benefitting programs. Reductions in engineering integration and payload integration manpower as a result of increased efficiencies stemming from cost reduction efforts underway within Shuttle Operations offset most of this increase. In addition, flight software support and planned upgrades have been reduced based on a reassessment of software requirements. Finally, allowances for unanticipated changes were reduced based on a re-estimate of change traffic.

BASIS OF FY 1994 ESTIMATE

The Flight Operations portion of the Shuttle Operations budget primarily supports efforts at JSC to plan for and conduct Shuttle missions from launch to landing. The functions are essentially the same as in the past: to maintain and operate all the ground facilities necessary for flight preparation and execution; to instruct the flight and ground controller crews; to maintain the proficiency and readiness of operational aircraft for training and orbiter ferry requirements; and to provide real time support to each Shuttle mission. Support will be provided to the missions to be flown in FY 1994 and to the initial efforts for flights in FY 1995 and FY 1996. These projects will continue their reductions into the outyears by critically reviewing their current requirements and identifying new ways of doing business in order to determine the minimum resource level needed to support the manifest without compromising flight safety.

BASIS OF FY 1994 FUNDING REQUIREMENT

FLIGHT HARDWARE

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Orbiter	430.700	522.700	540.853	508.900
Solid rocket booster (SRB)	542.000	556.700	559.100	515.700
External tank (ET)	354.100	375.900	298.200	340.000
Total	1,326.800	1,455.300	1,398.153	1,364.600

OBJECTIVES AND STATUS

The Flight Hardware budget buys the major hardware elements that are launched with the Shuttle and the sustaining engineering to support this hardware. This line includes funding for various orbiter items including the main engines along with the deliveries of solid rocket boosters (SRB) and external tanks (ET).

Orbiter flight hardware consists of the following items: (1) Orbiter spares for the replenishment of Line Replacement Units (LRUs) and Shop Replacement Units (SRUs) along with the manpower required to support the orbiter logistics program; (2) production of ET disconnect hardware; (3) overhaul and repair of main engine components, procurement of main engine spare parts, and main engine flight support and anomaly resolution; (4) flight crew equipment processing as well as flight crew equipment spares and maintenance; and (5) various orbiter support hardware items such as pyrotechnic initiated controllers (PICS), NASA standard initiators (NSIs), and overhauls and repairs associated with the Remote Manipulator System (RMS). In addition, beginning in FY 1993, the sustaining engineering associated with the orbiter vehicles is now included in this budget line. Previously, orbiter sustaining engineering had been funded under the integration line in the Flight Operations budget.

SRB funding covers deliveries of the Redesigned Solid Rocket Motor (RSRMs) as well as the deliveries of the SRB forward and aft assemblies. The RSRM budget includes: (1) purchase of solid rocket propellant; (2) necessary manpower to repair and refurbish flown rocket segments; (3) manpower to assemble individual case segments into casting segments and other production operations including shipment to the launch site; and (4) engineering manpower required for flight support and anomaly resolution. The remaining SRB budget funds: (1) procurement of new hardware and materials needed to support the flight schedule; (2) work at various vendor locations throughout the country for the repair of flown components; (3) manpower at the prime contractor facility for integration of both used and new components into a forward and an aft assembly; and (4) sustaining engineering for flight support.

Although the external tank program is continuing to deliver hardware at a minimum level until the excess inventory of tanks is depleted, production is beginning to ramp up to support increased deliveries required in the outyears. The production of tanks involves the following: (1) procurement of materials and components from vendors; (2) manpower at the Government Owned Contractor Operated (GOCO) facility to manufacture tanks; (3) support manpower and other costs to operate the GOCO facility; and (4) sustaining engineering for flight support and anomaly resolution. In the past year, the contractor has taken major steps to reduce the manpower and costs needed to deliver this hardware.

CHANGES FROM FY 1993 BUDGET ESTIMATE

In total, Flight Hardware funding has decreased $57.1 million. Orbiter flight hardware has increased $18.2 million due to re-estimates of efforts to process crew equipment items between flights, labor rate increases on the main engine, and acquisition of additional logistics items such as fuel cells and mission kits. Partially offsetting these increases have been reductions in orbiter sustaining engineering and backup flight software activities. The SRB funding has increased $2.4 million primarily due to the need to procure long-lead items for the next buy of RSRMs. In addition, the ROS restructure has required more institutional tasks to be funded by the SRB program. A major reduction of $77.7 million in funding for the external tank has occurred due to a variety of factors. The largest contributor to this reduction is in the area of contractor staffing. Specifically, the contractor is planning to reduce his direct and indirect manpower by about one thousand by the end of the calendar year. This reduction is possible because of increased efficiencies realized in the assembly of tanks as well as a critical review of indirect manpower requirements. Fee accrual also decreased due to contract concessions and revisions in fee accrual methodology. The balance of the reduction is due to additional efficiencies in the areas of make versus buy, vendor oversight, and plant operations and project support activities.

BASIS OF FY 1994 ESTIMATE

Requirements for orbiter flight hardware items are based on the flight rate, maintenance schedules, operational usage, repair times, and lead times to procure new hardware or repair flown hardware. Both the SRB and ET requirements in FY 1994 are driven by the planned flight model for not only FY 1994, but the outyears as well. The flight hardware elements have been subjected to a very aggressive cost reduction program as a result of the cost targets agreed to last year and additional cost reductions mandated in the current budget by NASA management. These projects are planning to continue their reductions into the outyears by critically reviewing their current requirements and by exploring new ways of doing business in order to determine the minimum resource level needed to support the manifest without compromising flight safety.

BASIS OF FY 1994 FUNDING REQUIREMENT

LAUNCH AND LANDING OPERATIONS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Launch operations.....	578,600	581,100	632,000	637,500
Payload and launch support.....	64,300	58,800	58,800	58,900
Total.....	642,900	639,900	690,800	696,400

OBJECTIVES AND STATUS

Launch and Landing Operations provides for the manpower and materials to process and prepare the Shuttle flight hardware elements for launch as they flow through the processing facilities at Kennedy Space Center (KSC). Standard processing and preparation of payloads as they are integrated into the orbiter are also funded under this category, as is procurement of liquid propellants and gases for launch and base support. Support to landing operations at KSC, Edwards Air Force Base (EAFB) and contingency sites, as required, is also provided.

Operation of the launch and landing facilities and equipment at KSC involves refurbishing the orbiter, stacking and mating of the flight hardware elements into a launch vehicle configuration, verifying the launch configuration, and operating the launch processing system prior to lift-off. Launch operations also provides for booster retrieval operations, configuration control, logistics, transportation, and inventory management.

In addition, this budget includes other launch support services: the central data subsystem, which supports Shuttle processing as an on-line element of the launch processing system, is maintained and repaired; Shuttle related data management functions, such as work control and test procedures, are funded; equipment, supplies and services are purchased; and operations support functions are provided. Among these support functions are propellant processing, life support systems maintenance, railroad maintenance, pressure vessel certification, Shuttle landing facility upkeep, and equipment modifications. Range support provided by the Department of Defense (DOD) is funded here as well.

Payload and launch support funding provides propellants for launch operations and base support, and contractor support for the assembly of individual payloads into a total cargo. This element includes providing launch site support managers to payload customers and verifying the cargo-to-orbiter interface.

Operations, maintenance and logistics support are provided to cargo support equipment (such as cargo integration test equipment and multimission payload support equipment) and to the payload support areas (the Vertical Processing Facility, Operations and Checkout building, and Cargo Hazardous Servicing Facilities). Support required for maintaining the Dryden Flight Research Facility as a contingency landing site is also included.

CHANGES FROM FY 1993 BUDGET ESTIMATE

Funding requirements for Launch and Landing Operations have increased $50.9 million. The majority of this growth is the result of the Research Operations Support (ROS) restructuring which requires the operation and maintenance of launch complex 39 to be funded by the benefitting program which is Shuttle Operations. The activities now being included, for example, are security, fire protection, and utilities. The balance of the increase (about $19 million) is due to labor rate increases with the Shuttle Processing Contractor (SPC).

BASIS OF FY 1994 ESTIMATE

Launch operations funding in FY 1994 provides manpower and support services necessary for processing launches from KSC. This includes manpower to assemble the SRBs, mate the boosters and tanks, process the orbiter, mate the orbiter to the integrated SRBs and external tank, process and checkout integrated flight elements through launch, retrieve and disassemble the SRBs for refurbishment, and support landing of the orbiter either at KSC, at EAFB, or at a contingency landing site, if required. Funding also supports the manpower required for KSC sustaining engineering, provisioning, logistics, launch processing system operation and maintenance, and maintenance/modification of all other Shuttle-related ground support equipment and facilities including Launch Complex 39. As with the other elements of Shuttle Operations, the launch operations process is being subjected to cost reduction efforts and the contractor is reviewing ways of continuing to reduce manpower while supporting the manifest and maintaining current safety levels.

BASIS OF FY 1994 FUNDING REQUIREMENT

RESEARCH OPERATIONS SUPPORT

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Research operations support.....	251.700	279.600	174.883	177.700

OBJECTIVES AND STATUS

Research Operations Support (ROS) funding provides vital support to the civil service workforce and to the physical plant at the Centers and at NASA Headquarters. This funding supports the basic core administrative functions such as personnel, payroll, accounting, procurement, and legal counsel. It also supports centerwide services for civil service staff, such as mail, telephones, janitorial services, transportation, medical (other than astronaut), security, and fire protection as well as maintenance of roads, grounds, and all requirements of administrative buildings. Funding to support activities which directly benefit the NASA programs are included in the program budgets.

CHANGES FROM FY 1993 BUDGET ESTIMATE

In FY 1992, establishment of the ROS was initially accomplished by transferring funds contained in the Operation of Installation account in the Research and Program Management appropriation to the Research and Development and Space Flight Control, and Data Communications appropriations. During FY 1993, a more detailed examination of activities supported by ROS funding was conducted by the program offices to identify support directly related to program activities. Funding for activities dedicated to a single program was transferred to the benefitting program. A reduction of $47 million consistent with Congressional direction, has been accommodated against all NASA ROS funds. Within Shuttle Operations, the decrease of $104.7 million in ROS funding reflects the transfer of $84.7 million consistent with the restructuring activity and a reduction of $20.0 million consistent with Congressional direction.

BASIS OF FY 1994 ESTIMATE

The FY 1994 estimate is based on the restructuring of the ROS budget in FY 1993 to fund primarily the basic core of administrative functions. In addition, reductions have been implemented to respond to NASA's

internal commitment to holding down costs in all areas and also to the recent executive order mandating reductions in administrative expenses. As such, it reflects the minimum funding to support administrative and facility maintenance requirements at the NASA Centers and NASA Headquarters. This includes administrative services that support all civil service employees, maintenance of roads, grounds, and requirements of administrative buildings.

SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS

FISCAL YEAR 1994 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE

LAUNCH SERVICES

SUMMARY OF RESOURCES REQUIREMENTS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Small	32,600	27,900	25,272	26,200
Medium	58,100	67,300	61,451	77,500
Intermediate	45,000	54,800	41,100	63,200
Large	20,100	11,000	5,278	82,300
Upper stages	*(41,200)	56,500	47,700	51,100
Total	155,800	217,500	180,801	300,300

* A non-add. Upper Stages was funded under Space Transportation System (STS) Capability Development prior to FY 1993.

Distribution of Program Amount by Installation

Kennedy Space Center	8,000	7,300	9,600	10,300
Marshall Space Flight Center	--	55,400	47,301	51,100
Goddard Space Flight Center	83,900	78,800	77,600	93,400
Lewis Research Center	63,900	62,600	46,300	145,500
Headquarters	--	13,400	--	--
Total	155,800	217,500	180,801	300,300

OBJECTIVES AND STATUS

The Launch Services program provides a mixed fleet capability, which in conjunction with the Space Shuttle, satisfies NASA payload requirements. Payloads are assigned for launch on Expendable Launch Vehicles (ELVs) consistent with Shuttle use criteria established in NASA's FY 1991 Authorization Act and the Launch Services Purchase Act of 1990.

With the exception of the launch services being provided for the Cassini mission and some launches procured for the National Oceanic and Atmospheric Administration (NOAA) under a reimbursable agreement, all ELV launch services are being competitively procured by NASA from the private sector, whenever available, to launch civil government payloads in three performance classes:

(a) Small class - payloads up to 1000 lbs. in low Earth orbit
(b) Medium class - payloads up to 10,000 lbs.
(c) Intermediate class - payloads up to 20,000 lbs.

Large class missions with payloads up to 40,000 lbs. to low Earth orbit must be acquired through the Department of Defense (DOD) since no commercially-provided launch services are currently available for this size payload. Since large class vehicles are not available from the private sector, procurement of a Titan IV vehicle and launch services is provided through the U.S. Air Force for the 1997 launch of Cassini.

Beginning in FY 1993, funding required for Upper Stage vehicles is included within Launch Services. The Upper Stages budget includes requirements for the Inertial Upper Stage (IUS) and the Transfer Orbit Stage (TOS). The last TOS vehicle contracted for, in support of the Advanced Communications and Technology Satellite (ACTS) mission, will be launched in mid-1993.

In September 1991, a contract with Orbital Sciences Corporation (OSC) was awarded to provide Small Expendable Launch Vehicle (SELV) services using the Pegasus vehicle. In November 1990, a contract with McDonnell-Douglas was signed to provide Medium Expendable Launch Vehicle (MELV) services using the DELTA II vehicle. A competitive request for proposal will be released in 1993 to provide for a series of potential Intermediate Expendable Launch Vehicle (IELV) missions. These potential missions include the Tracking and Data Relay Satellite (TDRS) system, the Geostationary Operational Environmental Satellite (GOES) series, Earth Observing System (EOS) missions, as well as some potential international cooperative missions.

CHANGES FROM 1993 BUDGET ESTIMATE

The Congressionally-directed reduction of $40.5 million has been accommodated by eliminating all program reserves, postponing all non-essential tasks to FY 1994, and adjustment of some payment schedules for commercial launches. Supporting launch services for all currently-planned launches has been maintained. These adjustments have been partially offset by a $3.8 million increase due to the redistribution of Research Operations Support (ROS) funding.

BASIS OF FY 1994 ESTIMATE

In FY 1994, funding is required for SELVs in order to support the launch of the Total Ozone Mapping Spectrometer (TOMS) and the Fast Auroral Snapshot Explorer (FAST) in 1994. Other missions being supported with SELV funds are the Satellite de Applicaciones Cientificas-B (SAC-B)/High Energy Transient Experiment (HETE) scheduled for a launch in late 1994, and the Submillimeter Wave Astronomy Satellite (SWAS) scheduled for a 1995 launch.

The FY 1994 funding for launches utilizing MELVs include the Wind and Polar missions (1994), the Radarsat cooperative mission with Canada (1994), and the X-ray Timing Explorer (XTE) (1995). The integration and launch costs for three secondary payloads to be launched from the East Coast on DOD Delta II vehicles is also funded. Initial funding is also included for the Advanced Composition Explorer (ACE) mission, the next Explorer mission, scheduled for a 1997 launch.

The majority of the funding required in FY 1994 for Intermediate Class ELVs is for an ATLAS-IIAS in support of the Solar and Heliospheric Observatory (SOHO) mission to be launched in 1995. Also included is funding for the EOS AM-1 mission (1998), including non-recurring costs and other modifications associated with launch and operations at the Western Test Range; and the first ELV-launched TDRS-G (1997). This first launch of the EOS series is planned for 1998.

Large class ELV funding is required for a Titan IV vehicle to support the Cassini mission, scheduled for an October 1997 launch. These funds also support the required Centaur upper stage, with both vehicle elements being purchased as a package from the U.S. Air Force. The Advanced X-ray Astrophysics Facility-I (AXAF-I) mission is currently baselined on the Shuttle for a 1998 launch. However, NASA is also aggressively pursuing an arrangement with the Air Force to use a Titan IV/Centaur vehicle for this launch.

In the Upper Stage budget, requirements for the IUS include the final Shuttle launch of the TDRS-F into geosynchronous orbit in 1995. The AXAF-I launch in 1998 would require an upper stage if it is launched on the Shuttle as now baselined. However, final launch vehicle selection has not yet been made, and NASA is actively pursuing a possible Titan IV/Centaur launch for this program.

SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS

FISCAL YEAR 1994 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE COMMUNICATIONS

SPACE AND GROUND NETWORKS, COMMUNICATIONS AND DATA SYSTEMS

SUMMARY OF RESOURCES REQUIREMENTS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate	Page Number
		(Thousands of Dollars)			
Space network	338,875	298,200	230,085	173,900	SF 4-4
Ground networks	283,000	314,600	306,901	315,980	SF 4-12
Communications and data systems	281,400	308,200	299,244	330,620	SF 4-21
Total	903,275	921,000	836,230	820,500	
Distribution of Program Amount by Installation					
Ames Research Center	13,000	16,100	15,663	17,700	
Goddard Space Flight Center	581,823	607,800	532,521	516,780	
Headquarters	73,491	46,500	42,046	40,400	
Jet Propulsion Laboratory	177,739	186,100	187,400	185,800	
Johnson Space Center	21	--	200	--	
Kennedy Space Center	700	--	--	--	
Langley Research Center	1	--	--	--	
Lewis Research Center	200	200	200	200	
Marshall Space Flight Center	56,300	64,300	58,200	59,620	
Total	903,275	921,000	836,230	820,500	

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SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS

FISCAL YEAR 1994 ESTIMATES

OFFICE OF SPACE COMMUNICATIONS

SPACE AND GROUND NETWORKS, COMMUNICATIONS AND DATA SYSTEMS

OBJECTIVES AND JUSTIFICATION

The purpose of this program is to provide the vital tracking, telemetry, command, data acquisition, communications, and data processing required by all NASA flight projects. Some of these capabilities are provided on a reimbursable, noninterference basis to projects of other Government agencies, commercial firms, and international organizations.

These capabilities are provided to meet the requirements of NASA's Earth orbital, planetary, and solar system exploration spacecraft missions, research aircraft, and sounding rockets and balloons. Included in Earth orbital activities are the Space Transportation System (STS), Spacelabs, and scientific and applications missions. The various capabilities provided include: (a) tracking to determine the position and trajectory of vehicles in space; (b) acquisition of science and space applications data from on-board experiments and sensors; (c) acquisition of engineering data on the performance of spacecraft and launch vehicle systems; (d) reception of television transmissions from space vehicles; (e) transmissions of commands from ground facilities to the spacecraft; (f) voice communications with astronauts; (g) transfer of information between the various ground facilities and control centers; and (h) processing of data acquired from the launch vehicles and spacecraft. These capabilities are essential for operating and maintaining U.S. space assets to achieve the scientific objectives of all flight missions and for executing the critical decisions necessary to the success of these missions.

NASA has three separate tracking networks to meet the requirements of NASA flight missions. These are: the Spaceflight Tracking and Data Network (STDN), for launch vehicles including STS launch and landing operations; the Deep Space Network (DSN), for planetary and interplanetary flight missions, high Earth-orbital missions, and low Earth-orbital missions that are unable to communicate through the Space Network; and the Space Network, which includes the Tracking and Data Relay Satellite System (TDRSS), required by most low Earth-orbital missions. The Space Network and STDN are managed by the Goddard Space Flight Center (GSFC). The DSN is managed by the Jet Propulsion Laboratory (JPL).

NASA has two communications networks: NASA Communications (NASCOM), which is managed by the GSFC, and the Program Support Communications Network (PSCN), which is managed by the Marshall Space Flight Center (MSFC). The NASCOM interconnects the tracking networks with the spacecraft control centers and data processing facilities associated with each mission. This network provides three classes of service: a relatively low data rate system for the launch and landing facilities at the Kennedy Space Center (KSC) and the Dryden

Flight Research Facility (DFRF); a medium rate system for the DSN; and a high rate system for the Space Network. The PSCN provides computer networking, voice and video conferencing, facsimile and electronic mail to all NASA programs and projects. The PSCN network interconnects all NASA locations and selected contractor sites via wideband terrestrial and satellite facilities.

Highly specialized computation facilities provide real-time information for mission control and data processing of the scientific, applications, and engineering data which flow from flight projects. In addition, instrumentation facilities are utilized for sounding rocket and balloon launchings and flight testing of aeronautical research aircraft.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The current estimate of $836.2 million for FY 1993 is $84.8 million below the budget request and is consistent with Congressional action. This funding level includes an increase of $5.2 million due to the redistribution of the Research Operations Support (ROS) account offset by the directed reduction of $65.0 million for TDRS II, and a general reduction of $25.0 million. This general reduction is accommodated within the Space Network (-$4.9 million), Ground Networks (-$8.3 million), and Communications and Data Systems (-$11.8 million).

Within the Space Network, the FY 1993 budget reflects increased funding requirements of $28.6 million for the Second TDRSS Ground Terminal, $6.1 million for Systems Engineering, and an increase of $1.8 million transferred from the ROS account. This is offset by reduced funding requirements of $14.0 million for the basic TDRS system and operations, reducing Replacement Spacecraft by $10.8 million and deleting $9.9 million associated with the suspended procurement of TDRS II replenishment spacecraft. As directed by Congress, $15 million is being made available to upgrade the existing Network Control Center.

BASIS OF FY 1994 ESTIMATE

The FY 1994 budget reflects an increasing level of flight programs plus the development and implementation activities to meet future mission requirements. A significant portion of the budget is driven by the requirements of operational spacecraft. Among these spacecraft are: Galileo; Mars Observer; Hubble Space Telescope (HST); Ulysses; the Compton Gamma Ray Observatory; Cosmic Background Explorer, (COBE); the Upper Atmosphere Research Satellite (UARS); Solar Anomalous and Magnetospheric Particle Explorer (SAMPEX); Extreme Ultraviolet Explorer (EUVE); Ocean Topography Experiment (TOPEX); Pioneer spacecraft; Voyager spacecraft; and the Shuttle missions. Funds are also required in FY 1994 to support approved missions currently under development. During FY 1994, the F-7 replacement TDRS spacecraft, which is planned for launch in FY 1995, will undergo integration and test; the Second TDRSS Ground Terminal (STGT) will initiate operations; and contract award for TDRS replenishment spacecraft will occur.

BASIS OF FY 1994 FUNDING REQUIREMENT

SPACE NETWORK

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Tracking and data relay satellite system (TDRSS)	63,406	46,200	32,116	23,300
Space network operations	40,968	61,900	58,163	36,700
Systems engineering and support	44,001	59,900	66,706	32,500
TDRS replacement spacecraft	43,568	10,800	--	5,700
Second TDRSS ground terminal	140,100	44,500	73,100	27,700
TDRS II spacecraft	6,832	74,900	--	--
TDRS replenishment spacecraft	--	--	--	48,000
Total	338,875	298,200	230,085	173,900

OBJECTIVES AND STATUS

The Space Network consists of the Tracking and Data Relay Satellites (TDRS) and the associated ground elements necessary to meet the communications requirements of Earth orbital spacecraft missions. The current TDRS constellation consists of two fully functional satellites, and two partially functional satellites. Another satellite, launched in January 1993, will serve as a fully functional spare. One partially functional satellite is being operated to reduce schedule overloads during Shuttle missions, and the other will be repositioned to increase data return from the Compton Gamma Ray Observatory, which has recorder problems. The ground facilities are located in White Sands, New Mexico. Satellite and ground communication links interconnect the White Sands facilities with the Network Control Center (NCC) at the Goddard Space Flight Center (GSFC) and other spacecraft mission facilities.

The increased funding required by the Second TDRSS Ground Terminal (STGT) has been accommodated by realigning other program funds.

The FY 1994 request includes funding for: maintenance and operations of the White Sands complex and the NCC; systems engineering and mission planning; equipment modification and replacement; continued development of the replacement spacecraft; the continued development of the second ground terminal and modernization of the first ground terminal at White Sands; and initiation of the TDRS replenishment spacecraft program.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Tracking and data relay satellite system (TDRSS)	30,731	46,200	32,116	23,300
Federal finance bank payment	32,675	--	--	--
Total	63,406	46,200	32,116	23,300

OBJECTIVES AND STATUS

The TDRSS serves as the communication link between the spacecraft operating in Earth orbit and ground facilities. The TDRS provides space-to-space communications with the orbiting spacecraft and relays data and command to and from the White Sands ground facilities which are interconnected with project control centers and other facilities.

The Space Network has provided data communications to the Shuttle missions, including Spacelabs; and orbiting satellite missions such as the Earth Radiation Budget Satellite (ERBS), the Cosmic Background Explorer (COBE), the Hubble Space Telescope (HST), the Compton Gamma Ray Observatory, Upper Atmosphere Research Satellite (UARS), Extreme Ultraviolet Explorer (EUVE), and Ocean Topography Experiment (TOPEX).

The TDRS-4 and TDRS-5 are fully functional, with one positioned in the west and the other in the east. The TDRS-6 was successfully launched in January 1993 to serve as a central back up. The two partially degraded spacecraft, TDRS-1 and TDRS-3 will be utilized to increase data return from the Compton Gamma Ray Observatory and to reduce schedule overloads during Shuttle missions, respectively.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The decrease of $14.1 million reflects $14.6 million program savings that were achieved as a result of contract negotiations and crew sharing with the Replacement Spacecraft program; reduced ground operations indirect costs; and an increase of $0.5 million to accommodate the Research Operations Support (ROS) transfer.

BASIS OF FY 1994 ESTIMATE

During FY 1994, operations and maintenance activities will continue at the White Sands complex. The spacecraft portion of the program will have been completed.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Space network operations.....	40,968	61,900	58,163	36,700

OBJECTIVES AND STATUS

The primary objective of Space Network Operations is to provide for the operation and maintenance of the ground systems and facilities required to schedule, control and operate the network system. This network operations system provides the planning, training, staffing, and preparation for upcoming missions necessary to assure the operational network capability required by the space missions in low Earth orbit.

The NASA Ground Terminal (NGT) at White Sands monitors TDRSS performance, provides fault isolation monitoring for the network, and serves as the communications interface with all other facilities. The White Sands Ground Terminal (WSGT) controls and operates the TDRS satellites and relays all telemetry and commands to and from the customer spacecraft. The STGT at White Sands will be fully staffed and prepared for the initiation of operations in the first quarter of CY 1994. This new facility will operate in parallel with the WSGT for a period, and then assume the operational role while WSGT is undergoing modernization. The NCC at GSFC manages and schedules TDRSS services for all customer spacecraft.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The decrease of $3.7 million includes an increase of $0.6 million transferred from the ROS account and a decrease of $4.3 million in program adjustments that are being made to accommodate a portion of the reductions specified by Congress. This was accomplished by reductions in training, documentation, NGT operations, and various other activities.

BASIS OF FY 1994 ESTIMATE

The requested funding provides for the operation of Space Network facilities 24 hours per day, seven days per week, and for related hardware and software maintenance. Funding is also provided for a variety of activities such as operational analysis, mission planning, simulations, compatibility testing, and documentation for missions requiring Space Network capabilities.

All responsibilities for Flight Dynamics Facility (FDF) operations, including orbit determination, mission acquisition, and position determination will be consolidated within the Communications and Data Systems program beginning in FY 1994. This transfer of responsibility will streamline overall management of the FDF.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Systems engineering and support.....	44,001	59,900	66,706	32,500

OBJECTIVES AND STATUS

The objective of Systems Engineering and Support is to provide the engineering services, hardware, and software development required to sustain and modify the Space Network elements. Systems engineering is supplied primarily through support service contracts. These contracts provide for equipment design and replacement, logistics, and specialized maintenance and operations activities including configuration management and procedure development. Ongoing activities include network integration and test, systems reliability analyses, test equipment procurement, and software modifications required for reliable operations.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The increase of $6.8 million reflects the addition of $9.9 million to develop implementation systems for improved Compton Gamma Ray Observatory data retrieval; an increase of $0.7 million transferred from the ROS account; and a decrease of $3.8 million in cancellation and reductions to studies and long range planning and analytical engineering efforts.

The majority of the directed funding for NCC improvement is provided by this budget element.

BASIS OF FY 1994 ESTIMATE

Funds are requested to provide systems engineering, hardware and software maintenance, sustaining engineering, test equipment, and vendor services for specialized equipment and Space Network subsystems. Funding includes NCC hardware replacement and the software modifications required to interface with the STGT.

Consistent with the decision to consolidate all responsibilities for FDF management within the Communications and Data Systems program, all FDF sustaining activities previously budgeted within Systems Engineering and Support will be transferred beginning in FY 1994.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
TDRS replacement spacecraft (F-7).....	43,568	10,800		5,700

OBJECTIVES AND STATUS

The objective of this program is to provide the TDRS-7 spacecraft, which is required to maintain the TDRS constellation. This spacecraft is functionally identical to the previous six satellites. Design changes have been made to improve reliability and to accommodate subsystems and parts that are no longer being produced. Final hardware deliveries will occur in FY 1993, and integration and test activities will resume. A second source has been secured for solid-state power amplifiers, solving long standing technical problems.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The decrease of $10.8 million is due to the restructuring of the integration and test phase of TDRS-7 to a later period. The restructuring reflects sharing of the crew with the TDRSS program during the TDRS-6 launch activities. FY 1993 activities will be carried out with prior year funding planned for the earlier integration and test schedule.

BASIS OF FY 1994 ESTIMATE

The requested funds will continue spacecraft and payload integration and test activities in FY 1994. Thermal vacuum spacecraft testing will be completed, integration systems test completed, and final assembly initiated. TDRS-7 is planned for launch in FY 1995 on the Shuttle.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Second TDRSS ground terminal (STGT)....	140,100	44,500	73,100	27,700

OBJECTIVES AND STATUS

The objectives of the STGT program are: to eliminate the Space Network's critical single point of failure at the existing ground terminal at White Sands, New Mexico; to upgrade the existing ground terminal for more

reliable and more cost-effective operations; to provide additional capability that allows continued use of partially failed spacecraft; and to provide the capability of performing ground terminal maintenance and modifications on the existing terminal without interruption to Space Network operations.

The hardware chassis fabrication is complete for all six Space-to-Ground Link Terminals (SGLT) and the subsystem testing to validate the hardware and software functionality continues. Systems level testing conducted at the STGT site was initiated in parallel with subsystem tests. Most of the STGT equipment has been delivered to the site and is undergoing test and all the required cable has been installed. The pace of activity there will continue to increase as hardware installation, procedure development, and other preparations for the initiation of final acceptance testing continue. System level testing is scheduled to be completed by the end of FY 1993.

CHANGES FROM FY 1993 ESTIMATE

The increase of $28.6 million is to accommodate the cost growth incurred during FY 1993. The cost increase was driven by lack of engineering model hardware, underestimates of the complexity of hardware and software development, and subcontractor technical problems. Details on the cost growth are available in the Special Report on STGT provided to the House and Senate Committee on Appropriations on September 18, 1992. Initial operations capability for the STGT is now scheduled for the end of January 1994.

BASIS OF FY 1994 ESTIMATE

The funding requested will provide for network level testing and preparations for initial operations scheduled for January. As operational readiness is validated by STGT parallel operations with the White Sands Ground Terminal (WSGT), the integration and test of the remaining three SGLTs for the WSGT upgrade will be concluded. When the STGT assumes the operational load near the end of the fiscal year, the WSGT will be shut down, the old equipment removed, and the facility remodeled for the installation of the remaining three SGLTs.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Tracking and data relay satellite (TDRS) II	6,832	74,900	--	--

OBJECTIVES AND STATUS

The objective of the program is to design, develop, and competitively procure improved relay satellites required for continuity of Space Network operations through the next decade. TDRS II includes a Ka-band single access service that operates in a new protected frequency band to reduce the possibility of harmful interference. This frequency will also make TDRS compatible with future international systems (Japan and Europe). TDRS II includes an enhanced multiple access capability which utilizes existing phased array technology to increase antenna gain: this will permit off loading customers from scarce single access antennas, thereby reducing the number of TDRS II satellites required. Ground system modifications to accommodate these new services are included in the procurement.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The decrease of $74.9 million is in response to a directed Congressional reduction and subsequent cancellation of the TDRS II procurement. The TDRS II procurement of six spacecraft was first suspended to assess alternatives, including an unsuccessful effort to procure a single spacecraft of the existing design. A search for more affordable alternatives led to canceling TDRS II and initiating procurement of spacecraft functionally equivalent to the existing design as an interim solution to NASA's pressing needs.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Tracking and data relay replenishment spacecraft	--	--	--	48,000

OBJECTIVES AND STATUS

The Tracking and Data Relay Satellite System program has been very successful over its ten year history. While increasing NASA's global coverage from 15 to 85 percent and the data rates by a factor of six, 15 ground stations have been closed and operating costs reduced. The objective of the replenishment program is to ensure continuation of this essential capacity into the next century.

By the end of the decade many of the initial TDRS satellites will have exceeded their expected lifetime. Analyses indicate that without additional spacecraft, a substantial part of NASA's communications requirements for operating current and approved new missions cannot be met in the latter part of this decade. Present programs such as the Space Transportation System (STS), HST, Compton Gamma Ray Observatory, TOPEX plus approved future NASA missions preparing for launch--a dozen missions representing a major investment --cannot accomplish their objectives without a reliable Space Network. The risks to these programs must be balanced by a continuing capital investment in replenishment spacecraft.

Since three spacecraft are needed in close succession, all will be incorporated in this interim procurement. The early funding profile will not be increased significantly for a multiple spacecraft buy. More importantly, total runout costs will be substantially reduced compared with individual buys. The total costs will be lower due to a common design, assembly, and test procedures, and parts buys. Also lower costs will result from the increased competition of a multiple buy.

A development contract will be competitively awarded in mid-1994. This contract will be fixed price to ensure cost containment. The fixed price approach is made possible with the spacecraft specification based on the functional equivalent of the original TDRS service. (Identical spacecraft of the previous design will be acceptable.) A higher performance phased array antenna will be considered if it is cost effective. Any associated ground systems modifications will be included in the scope and costs, and life-cycle cost evaluations will be a part of the selection process. Although launch services will be separately funded and government provided, selection will consider overall cost to the government.

<u>BASIS OF FY 1994 ESTIMATE</u>

The requested funding will provide for a development contract award in mid-1994. The first replenishment spacecraft is expected to be available for launch in mid-1998.

BASIS OF FY 1994 FUNDING REQUIREMENT

GROUND NETWORKS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Spaceflight tracking and data network systems implementation	3,100	5,500	5,526	6,100
Spaceflight tracking and data network operations	56,040	64,500	61,596	60,700
Deep space network systems implementation	79,560	82,600	80,301	89,900
Deep space network operations	106,750	119,000	118,000	112,100
Aeronautics, balloons, and sounding rocket systems implementation	15,700	17,600	17,591	20,500
Aeronautics, balloons, and sounding rocket operations	21,850	25,400	23,887	26,680
Total	283,000	314,600	306,901	315,980

OBJECTIVES AND STATUS

Three broad categories of missions depend on the Ground Networks: (1) Earth orbital; (2) planetary and solar system exploration; and (3) aeronautics, balloons, and sounding rocketa. The Deep Space Network (DSN) is required for the planetary and solar system exploration missions as well as Earth orbital missions not compatible with the Tracking and Data Relay Satellite System (TDRSS) Space Network. Aeronautical, balloon and sounding rocket research requires specially instrumented ranges as well as mobile stationa. The Spaceflight Tracking and Data Network (STDN) stations at Merritt Island, Florida, Bermuda, and Dakar, Senegal, are required during the launch phase of Space Transportation System (STS) missions. Both the DSN and STDN stations also provide emergency coverage of Earth-orbiting spacecraft if they become unable to communicate through the TDRSS Space Network. Range safety functions are provided via Bermuda and Wallops. The requirementa of Space Transportation Systems (STS) landings at the Dryden Flight Reaearch Facility (DFRF) are met by the Western Aeronautical Teat Range (WATR) at DFRF and the DSN facilities at Goldstone. The Wallopa Flight Facility (WFF) is used for tracking orbital scientific spacecraft. STS, Expendable Launch Vehicles (ELV's), and routine aeronautic, balloon, and aounding rocket activitiea.

The Ground Networks program funding provides the operation and maintenance of the worldwide tracking facilities. Implementation funds are used for the design, development, and implementation of hardware and software to service NASA flight mission operations.

The workload in FY 1994 will include the STS, ELV's, Mars Observer, Galileo, Total Ozone Mapping Spectrometer (TOMS), Ulysses, International Solar Terrestrial Physics (ISTP), High Resolution Microwave Survey (HRMS), Solar Anomalous and Magnetospheric Particle Explorer (SAMPEX), Fast Auroral Snapshot Explorer (FAST), Pioneers-10 and -11, International Cometary Explorer (ICE), and the Voyager-1 and -2 in addition to aeronautic, balloon, and sounding rocket missions. Preparations are under way for missions such as Cassini, future Small Explorer (SMEX) and cooperative missions, such as the Advanced Earth Observing Satellite (ADEOS) Japanese mission, and the cooperative Synthetic Aperture Radar Satellite (RADARSAT) mission with Canada. Work is in progress to prepare for two Radio Astronomy cooperative missions -- the Russian Radioastron project, and the Japanese Orbiting Very Long Baseline Interferometry Project (VSOP).

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Spaceflight tracking and data network (STDN) systems implementation	3,100	5,500	5,526	6,100

OBJECTIVES AND STATUS

The STDN systems implementation program encompasses the procurement of hardware and engineering services to sustain, modify, and replace existing ground network capabilities to ensure reliable tracking, command and data acquisition required by NASA's STS missions.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The increase in FY 1993 funding is due to the transfer of funds from the Research Operations Support (ROS) account.

BASIS OF FY 1994 ESTIMATE

The FY 1994 request provides funds to upgrade equipment and subsystems required for the STS operations at the Merritt Island, Florida, and Bermuda STDN tracking stations. Funding is also provided for the replacement of obsolete, difficult-to-maintain equipment. Specific FY 1994 projects include replacement of obsolete antenna control consoles and radar rehabilitation.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Spaceflight tracking and data network (STDN) operations	56,040	64,500	61,596	60,700

OBJECTIVES AND STATUS

The primary function of the STDN is to provide prelaunch, launch, and landing communications required by the STS. In addition, this network provides emergency communications to orbiting spacecraft in the event that they are unable to communicate through the TDRSS/Space Network. The network also meets similar requirements of other U.S. government agencies, private industry, and international organizations on a reimbursable basis.

The STDN consists of three ground stations located at Bermuda; Merritt Island, Florida; and Dakar, Senegal. Each station is capable of tracking spacecraft, transmitting commands for spacecraft and experiment control, and receiving engineering and scientific data from the spacecraft. They also provide primary and backup voice communications for STS operations and range safety functions for the Eastern Range.

The STDN logistics program includes a supply depot, a magnetic tape acquisition and certification facility, and centralized equipment repair and shipping facility. The depot is operated as a centralized facility and services the Communications and Data Systems program; the Deep Space Network; the Space Network; the Aeronautics, Balloons, and Sounding Rocket program; and the STDN. It is managed by the Goddard Space Flight Center (GSFC).

CHANGES FROM FY 1993 BUDGET ESTIMATE

The decrease of $2.9 million includes a decrease of $3.0 million being made to accommodate a portion of the general reduction specified by Congress that will be achieved by a drawdown of spare parts from the logistics depot, and an increase of $0.1 million resulting from the transfer of ROS funds.

BASIS OF FY 1994 ESTIMATE

The FY 1994 request provides for the operation and maintenance of the three ground stations, centralized logistics operations, and limited tracking purchased from the Department of Defense (DOD) and the University of Chile.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Deep space network (DSN) systems implementation	79,560	82,600	80,301	89,900

OBJECTIVES AND STATUS

The primary role of the DSN is to provide communication between interplanetary spacecraft and the Earth. The DSN receives science and engineering telemetry, and transmits command, control and navigation signals to a variety of spacecraft at distances as great as 8 billion kilometers from Earth. The major objectives of the DSN are: (1) to communicate with scientific spacecraft at ever greater distances and to increase the ability to receive data from the far reaches of the solar system; (2) to communicate with Earth-orbiting spacecraft that are non-TDRSS compatible; (3) to provide navigation for precision spacecraft targeting and probe delivery; and (4) to provide the capacity and capability to service future NASA missions.

The systems and facilities required by spacecraft at the limits of the solar system are highly specialized and include large aperture antennas, which can receive extremely weak radio signals. These antennas use ultra-sensitive receivers and powerful transmitters. Extremely stable time standards are required for precise navigation of distant spacecraft. Advanced data handling systems are required at both the Network Operations Control Center located at the Jet Propulsion Laboratory (JPL) and the Deep Space Communications Complexes located in California, Spain, and Australia. An orderly, phased upgrade program has been established to increase DSN capacity and incorporate new required capabilities for current and future missions. These improvements are needed to accommodate the increasing number and sophistication of spacecraft. Specific improvements include additional antenna subnetworks, which can be arrayed together (combined electronically) to effectively improve performance and implementation of systems for two cooperative Orbiting Very Long Baseline Interferometry (OVLBI) Astronomy mission, VSOP and Radioastron; Cassini; Galileo; the High Resolution Microwave Survey (HRMS); and two joint Earth observation missions, RADARSAT and ADEOS.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The decrease of $2.3 million reflects program adjustments that are being made by deferring and delaying various activities to accommodate a portion of the general reduction specified by Congress.

BASIS OF FY 1994 ESTIMATE

The FY 1994 budget includes funding for activities necesaary to assure the availability of alternate miaaion capabilities for Galileo. It also provides for a new DSN 11-meter antenna subnet and completion of modification to the Green Bank Radio Observatory's 14-meter antenna for use in the OVLBI cooperative missions with NASA's Russian and Japanese partners. The FY 1994 budget funds sustaining activities for DSN reliability and maintainability. This budget provides funding for multimission improvements needed to accommodate a variety of missions that will be operating in the mid-to-late 1990's including Cassini, International Solar Terrestrial Physics, and Mars Observer.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Deep space network operations.....	106,750	119,000	118,000	112,100

OBJECTIVES AND STATUS

The three DSN complex locations (Goldstone, California; Canberra, Australia; and Madrid, Spain) are approximately 120 degrees apart in longitude to permit continuous viewing of planetary spacecraft. Each complex has four antennas -- one 70-meter, two 34-meter, and one 26-meter. The 26-meter antennaa are required by some Earth-orbiting spacecraft, such as Nimbus-7, Solar-A, and Solar Anomalous, and Magnetospheric Particle Explorer (SAMPEX), and for spacecraft emergencies. The complexes are staffed for around-the-clock operations. A central network control center is located at the Jet Propulsion Laboratory (JPL) in Pasadena, California. Other DSN facilities include a spacecraft compatibility test area at JPL and a launch operations and compatibility facility at the Merritt Island Spaceflight Tracking and Data Network (STDN) site.

Since 1989, four interplanetary spacecraft, which require telecommunications with the DSN, have been launched -- Magellan, Galileo, Ulysses, and Mars Observer. Magellan began mapping the planet Venus in 1990, and mapped more than 99 percent of that planet before initiating studies of the gravity field. Galileo recently flew within 190 miles of the Earth on its final planetary assist as the spacecraft begins the initial phase of its journey to Jupiter. Later this year Galileo will fly near the asteroid Ida.

Ulysses flew past Jupiter in February 1992, where it received a gravity assist to deflect it on a trajectory to the Sun's polar regions. In September 1992, Mars Obaerver was launched and will arrive at Mars in August 1993. The DSN also provides communications for the Voyagers, the Pioneers, International Cometary Explorer (ICE), and the International Solar Terrestrial Physics (ISTP)/Geotail spacecraft.

In response to the increasing telecommunications requirements, the capacity of the DSN will be increased through the phased implementation of additional antennas throughout the next decade. The antennas are funded within the Construction of Facilities budget.

The DSN facilities are also used for ground-based solar system radar and radio astronomy observations. The network's ultra-sensitive antennas are being used in an attempt to learn more about pulsar high energy sources, quasars, and other interstellar and intergalactic phenomena. The solar system radar is useful in understanding surface characteristics of planets, asteroids, comets, moons, near-Earth asteroids, and ring systems. Radar observations were taken of the asteroid Toutatis late last year as it passed within 2.5 million miles of Earth.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The decrease of $1.0 million reflects program adjustments that are being made to accommodate a portion of the general reduction specified by Congress.

BASIS OF FY 1994 ESTIMATE

The DSN operations funding provides for the maintenance and operation of network facilities and the engineering required for continuing operation of the network. The expected DSN workload in FY 1994 includes Galileo, Ulysses, Mars Observer, Pioneer-10 and -11, Voyager-1 and -2, ICE, Nimbus-7, Solar-A, Geotail, Wind, Astro-D, Total Ozone Mapping Spectrometer (TOMS), SAMPEX, and STS. The DSN will also provide communications for spacecraft emergencies and serve as backup to the TDRSS Space Network. Major TDRSS users that have used ground-based emergency communications include STS, Hubble Space Telescope (HST), Compton Gamma Ray Observatory, Cosmic Background Explorer (COBE), Upper Atmospheric Research Satellite (UARS) and TOPEX.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Aeronautics, balloons and sounding rocket (AB&SR) systems implementation	15,700	17,600	17,591	20,500

OBJECTIVES AND STATUS

The Aeronautics, Balloons, and Sounding Rocket (AB&SR) systems implementation program is directed primarily at the replacement of obsolete systems and the upgrade of facilities to assure reliable service to NASA's research programs.

The tracking and data acquisition facilities receive the scientific and engineering data from research aircraft, balloons, sounding rockets and some Earth-orbiting spacecraft engaged in scientific reaearch. The primary fixed facilities are located at the WFF, the Ames Research Center (ARC), and the DFRF.

The WFF, a part of the GSFC, operates a range at Wallops Island, Virginia, conducts aeronautics research, sounding rocket and small meteorological balloon launches, and tracks Earth-orbiting satellites. The WFF also manages the operation of off-site ranges located at the White Sands Missile Range, New Mexico; Poker Flat Research Range, Alaska; and the National Scientific Balloon Facility, at Palestine, Texas, and Ft. Sumner, New Mexico. In cooperation with the National Science Foundation (NSF), a transportable facility will be provided at McMurdo Sound, Antarctica, to meet the requirements of the joint US/Canadian RADARSAT mission. Mobile campaigns for balloon and sounding rocket launches are conducted at various sites, as required, throughout the world. The funding in this budget is used to provide tracking and data acquisition for these activities.

The ranges at Moffett Field, Crows Landing and the DFRF are under the management of ARC and are configured for aeronautics research. The DFRF has the additional responsibility of providing tracking for STS landings.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The FY 1993 reduction reflects a decrease made to accommodate a portion of the general reduction specified by Congress, mostly offset by an increase due to the transfer of funds from the ROS account.

BASIS OF FY 1994 ESTIMATE

The aeronautical research efforts and scientific experiments using sounding rockets and balloons require fixed and mobile instrumentation systems. These include radar, telemetry, optical, communications, command, data handling and processing systems. The FY 1994 budget request includes funds to maintain these facilities, to replace test and calibration equipment, and refurbish or modify equipment to assure reliable performance. Funds are also included for acquisition of new mobile tracking systems for NASA's Small Explorer program, RADARSAT, and for the automation of the Wallops Orbiting Tracking Station.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Aeronautics, balloons, and sounding rocket (AB&SR) operations	21,850	25,400	23,887	26,680

OBJECTIVES AND STATUS

The operations element of the AB&SR program includes the operations and maintenance of ground-based tracking instrumentation systems, both fixed and mobile, under the management of the ARC and the GSFC. These facilities are employed for NASA aeronautics, sub-orbital, and a limited number of Earth-orbiting research programs. Funding provides for services required to operate and maintain the tracking radar, telemetry, data acquisition, data processing, data display, communications and special purpose optical equipment essential for these research programs.

The Western Aeronautical Test Range (WATR), composed of DFRF, Moffett, and Crows Landing facilities, maintains an aggressive schedule of aeronautics research operations. During FY 1992, 1,104 missions were conducted at DFRF and Moffett. The trend continues upward in FY 1993 with approximately 1,216 aeronautical missions planned. Programs tracked from these ranges included high performance aircraft, advanced technology research aircraft, and complex control systems and powered lift technologies. STS tracking and telemetry for landing operations are coordinated through DFRF.

The WFF provides tracking, telemetry, and command functions for NASA's aeronautics, sounding rocket, balloon, and some Earth-orbiting satellite programs. During FY 1992, 304 aeronautics missions were conducted. These were related to such programs as automatic landing operations using Global Positioning Satellite inputs, aircraft performance using vortex flap technology, the Pacific Joint Ocean Flux Study, the Greenland Ice Cap Measuring Program, the Shuttle Microwave Scanning Beam landing system checkout, the Puerto Rican El Coqui Sounding Rocket Campaign, WFF Range Surveillance, and runway friction testing. Approximately the same number of aeronautics missions will be conducted in FY 1993.

In FY 1992, WFF supported 76 sounding rocket missions from WFF and several worldwide sites which covered a variety of NASA and DOD science disciplines. Approximately 75 are planned for FY 1993. WFF is also the center for NASA Scientific Balloon operations and launched a total of 154 science research balloons in FY 1992, with approximately 100 planned for FY 1993.

In FY 1992, a new Integrated Range Control Center was completed and placed in operation at WFF. This facility combines both rocket launch and aeronautical test control centers into a single facility with the range computer complex.

A new 8-meter precision tracking telemetry antenna was placed in operation at the Poker Flat Research Range in Alaska for support of the NASA Plasma Physics Program.

A new precision tracking mobile C-Band radar passed final acceptance tests and was placed in operation.

In FY 1993, the Wallops Orbital Tracking Station will provide 24-hour space tracking operations for missions such as Cosmic Background Explorer (COBE), International Ultraviolet Explorer (IUE), Interplanetary Monitoring Platform-8 (IMP), Nimbus-7, Meteosat, NOAA-10, TOMS/Meteor-3, Roentgen Satellite (ROSAT) and SAMPEX.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The decrease of $1.5 million reflects an increase of $0.4 million being made as a result of transferring funds from the ROS account along with $1.9 million in program adjustments that are being made to accommodate a portion of the general reduction specified by Congress. This will require operations, engineering, and logistics reductions at WFF, as well as reductions in spares and test equipment at WATR.

BASIS OF FY 1994 ESTIMATE

The funding for the AB&SR Operations program includes contractor operations and maintenance personnel and technical services used to provide tracking, data acquisition, command and control for the ground-based fixed and mobile instrumentation systems for the ongoing sounding rocket, balloon, certain Earth-orbiting satellites, and aeronautical research programs. Funds are included necessary to prepare for Antarctic operations to meet Radarsat requirements, and for the operation and maintenance of the receiving ground station of the Alaska SAR Facility. Funds are also provided for aeronautics research operations and radar overhauls at the WFF and the DFRF.

BASIS OF FY 1994 FUNDING REQUIREMENT

COMMUNICATIONS AND DATA SYSTEMS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Communications systems implementation..	10,300	8,700	8,769	14,600
Communications operations.....	122,640	131,200	128,054	124,520
Mission facilities.....	14,000	17,100	14,241	18,500
Mission operations.....	48,400	52,500	50,336	52,700
Data processing systems implementation.	24,360	30,000	30,670	33,600
Data processing operations.....	61,700	68,700	67,174	86,700
Total.....	281,400	308,200	299,244	330,620

OBJECTIVES AND STATUS

The Communications and Data Systems program provides for the development and operation of facilities and systems that are required for data transmission, mission control and data processing for space flight missions. The demand for these services are increasing sharply as new flight missions are added to the continuing operations of older spacecraft. FY 1992 began with the continued operation of nine spacecraft: Upper Atmosphere Research Satellite (UARS), Compton Gamma Ray Observatory, Cosmic Background Explorer (COBE), Earth Radiation Budget Satellite (ERBS), Hubble Space Telescope (HST), International Cometary Explorer (ICE), Interplanetary Monitoring Platform-8 (IMP), International Ultraviolet Explorer (IUE), and NIMBUS. During the past year, two major explorers were launched: the Extreme Ultraviolet Explorer (EUVE) and the Solar Anomalous and Magnetosphere Particle Explorer (SAMPEX). Each explorer has corresponding spacecraft control and data processing facilities that were completed and placed into operation. The addition of the EUVE and SAMPEX explorers to NASA's operational fleet has resulted in an increase of approximately 40 percent in the quantity of scientific data processed on a continuous basis by the Office of Space Communications.

Communications circuits and services provide for the transmission of data between and among the remote tracking stations, the Tracking and Data Relay Satellite System (TDRSS) Ground Terminal, launch areas, the mission control centers, and data processing facilities. Real-time information is crucial to determine the condition of the spacecraft and payloads, responding to failures or dangerous situations, and for the generation of spacecraft and payload control commands. Data received from the various spacecraft must be transformed into a form usable for spacecraft monitoring in the control centers, and for analysis by the scientific investigation team.

In addition to operating spacecraft, preparations are under way for several new missions to be launched including Wind, Polar, Solar and Heliospheric Observatory (SOHO), Cluster, Fast Auroral Snapshot Explorer (FAST), Submillimeter Wave Astronomy Satellite (SWAS), X-ray Timing Explorer (XTE), Advanced Composition Explorer (ACE), Total Ozone Mapping Spectrometer-1 (TOMS-1), Earth Observing Satellite (EOS) AM-1, and the Tropical Rainfall Measurement Mission (TRMM). The Space Shuttle will carry several Spacelab and attached payloads into orbit this year, and data processing preparations are nearing completion for these missions.

To meet the increasing requirements in terms of both quantity of spacecraft being operated and the much larger volumes of data being produced by the newer spacecraft, it is necessary to modernize facilities to expand system capacity and replace aging equipment that is becoming increasingly costly to maintain. The application of advanced technologies such as high-speed Very Large Scale Integration (VLSI) and distributed systems using the new powerful microcomputers has been incorporated into our new facilities, e.g., Transportable Payload Operations Control Center (TPOCC) for SAMPEX and upcoming level zero processor (LZP) for FAST.

In the communications area, planning is continuing for the transfer of many of the domestic (intra-U.S.) transmission services of NASA's global communications network (NASCOM) for operational missions onto the FTS-2000 network. Because of the critical nature of NASCOM, special arrangements are being made with the General Services Administration (GSA) to provide the reliability and diversity requirements that the current NASCOM provides. When these arrangements are completed, circuit transfers will begin and will continue through FY 1993 and FY 1994. The transfer of services to FTS-2000 include those services that are less than 1.5 million bits per second (M b/s). The high speed data services (greater than 1.5 M b/s) and overseas services are beyond the scope of FTS-2000.

	1992	1993		1994
		Budget	Current	Budget
	Actual	Estimate	Estimate	Estimate
		(Thousands of Dollars)		
Communications systems implementation...	10,300	8,700	8,769	14,600

OBJECTIVES AND STATUS

The objective of the Communications Systems Implementation program is to provide the necessary capability in NASCOM to meet new flight program requirements, to increase the efficiency of the network, and to maintain a high level of reliability and security for the transmission of data and commands between U.S. assets in space and their respective control centers.

Major systems implementation projects expected to be completed in FY 1993 that were initiated in prior years include: (1) the upgrade of the data handling capability of the Deep Space Network (DSN) to 1.2 M b/s; (2) operational status of a fiber optic system connecting the two TDRSS ground terminals at the White Sands complex; and (3) the implementation of a new backbone multiplexer/demultiplexer (MDM) system between the White Sands complex, the Goddard Space Flight Center (GSFC), and the Johnson Space Center (JSC).

CHANGES FROM FY 1993 BUDGET ESTIMATE

The increase in FY 1993 reflects the transfer of funds from the Research Operations Support (ROS) account.

BASIS OF FY 1994 ESTIMATE

The FY 1994 funding will provide the necessary equipment acquisitions and sustaining engineering modifications required for completion of projects begun in earlier fiscal years. Of particular note are the completion of the digital voice system at GSFC; the acquisition of a new digital matrix switch at the GSFC for greater circuit handling capability; and the continuing upgrade of the DSN to meet the data requirements of the Wind, Polar, and SOHO missions, which are part of the International Solar Terrestrial Program (ISTP).

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
	(Thousands of Dollars)			
Communications operations.....	122,640	131,200	128,054	124,520

OBJECTIVES AND STATUS

The NASCOM network interconnects the tracking and data acquisition facilities for all flight projects via leased voice, data, video, and wideband circuits. The overseas elements of NASCOM employ a sub-switching center at the Jet Propulsion Laboratory (JPL) to improve diversity, connectivity to multiple overseas destinations, and to achieve optimum utilization of circuit bandwidth. Direct services from Madrid and Australia to the JPL were established in FY 1992 to economically provide the increased bandwidth required by new spacecraft under development.

The NASCOM program includes the Agency's television service, NASA SELECT, which allows the American public to witness all manned spaceflight missions and learn of the important discoveries of the scientific missions such as Magellan. NASA SELECT will continue to be used for educational outreach with a potential audience of most universities and high schools, and will continue its coverage to Hawaii and parts of Alaska in FY 1993.

NASA's Program Support Communications Network (PSCN) interconnects the NASA Centers, Headquarters, major contractors, and university locations for the transfer of programmatic and scientific information. The PSCN services include computer networking, electronic mail, and voice and video teleconferencing. The FTS-2000 is now providing the transmission system that services the PSCN. The Marshall Space Flight Center (MSFC) operates the PSCN and serves as its control center.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The decrease of $3.1 million reflects an increase of $1.6 million that was transferred from the ROS account along with program reductions to the PSCN that include delaying implementation of new requirements and deferring planned improvements of existing services. Planned augmentations have been deferred until FY 1995.

BASIS OF FY 1994 ESTIMATE

The requested FY 1994 funding for the communications operations program provides for the increased system capacity needed for the upcoming ISTP missions, along with the preparations necessary to continue operations of the newly completed TDRSS ground terminal at the White Sands complex. The PSCN provides for the circuits, facilities, and systems integration for programmatic and institutional communications operations. PSCN services include computer networking, voice and video conferencing, facsimile, and electronic mail. In FY 1994, funds are required for continued operation, maintenance, and systems integration of the PSCN hardware and wideband satellite and terrestrial circuits at all NASA locations and certain contractor sites. Network services are required by all NASA programs and projects.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Mission facilities.....	14.000	17.100	14.241	18.500

OBJECTIVES AND STATUS

The Mission Facilities program provides the systems and capabilities needed for the command and control of NASA's unmanned scientific satellites. Command and control of the spacecraft and on-board experiments are carried out by the respective Payload Operations Control Centers (POCCs) and their auxiliary facilities used for many spacecraft.

The POCCs are responsible for the receipt, processing, and display of spacecraft engineering data and the generation of commands. Five POCCs currently monitor and control 11 spacecraft. In FY 1992, mission control capabilities were implemented for EUVE, which is the last new spacecraft that will be controlled out of the aging Multi-Satellite Operations Control Center, and for the SAMPEX, which is the first spacecraft to be controlled using the new Transportable Payload Operations Control Center (TPOCC) architecture. Future spacecraft POCCs are being implemented in the TPOCC architecture with distributed workstations to take advantage of the increased processing capability and lower cost. Other related mission systems include a JSC/GSFC Shuttle POCC Interface Facility (SPIF) and a Mission Planning/Command Management System to generate command sequences for transmission by the POCCs to the spacecraft, and the User Planning System (UPS) to schedule spacecraft communications periods through the TDRSS.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The decrease of $2.9 million reflects program adjustments that are being made by deferring and delaying various activities to accommodate a portion of the general reduction directed by Congress.

BASIS OF FY 1994 ESTIMATE

The FY 1994 budget request includes funds for continued implementation of mission control capabilities at GSFC for the Small Explorer (SMEX) missions and replacement equipment for the Hubble Space Telescope (HST) control center, which will operate the HST spacecraft until at least FY 2004. Funds are also needed to procure equipment to implement control center facilities for the upcoming TRMM, SOHO, XTE, ACE, and TOMS missions.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Mission operations.....	48,400	52,500	50,336	52,700

OBJECTIVES AND STATUS

The Mission Operations program provides for the operation of the mission control centers and the related software and services necessary for the monitoring and control of in-orbit spacecraft and prelaunch preparations for new spacecraft.

Control facilities for spacecraft/payload operations have the capability for receiving, processing, and displaying spacecraft engineering data and for generating commands. Commands are generated in response to

emergencies and also preplanned in sequences and transmitted to the spacecraft to carry out the mission objectives. Software is developed for each new spacacraft, made up of approximataly 50 percent reuaed standard software and 50 percent new mission unique software. Each facility is operated 24 hours per day, 7 days per week for mission services. For Shuttle missions with attached payloads operated by GSFC, a specialized system processes and displays Shuttle-unique data that is needed for payload control.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The decrease of $2.2 million includes an increase of $0.3 million associated with the ROS account transfer along with a decrease of $2.5 million which results from a rephasing of the TRMM mission control software and deferral of institutional software systems.

BASIS OF FY 1994 ESTIMATE

The FY 1994 budget request includes funds to operate the control centers and facilities for control of 12 operational missions; to complete development of capabilities for three new missions to be launched in FY 1994; and to develop the control center capabilities needed for spacecraft under construction that will be launched beyond 1994. The funds will also be used for development of improvements to the planning, scheduling, and command generation system for the HST, a system to offload recording and analyses functions from the overloaded controlling computers, and to provide a system to schedule the use of the TDRSS when the new second TDRSS ground terminal (STGT) is in place. These enhancements are required to permit the control centers to operate with the evolving NASA ground systems, to control the increased number of spacecraft, and to accommodate the higher data rates and complexity of the new spacecraft.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Data processing systems implementation.	24,360	30,000	30,670	33,600

OBJECTIVES AND STATUS

The Data Processing Systems program provides for the procurement of equipment and development of data processing and computational systems at GSFC that are required by a broad range of Earth orbiting scientific missions. These systems determine spacecraft attitude and orbits, and generate attitude and orbit maneuvers for operating spacecraft. These systems also process the large volume of data produced by the operational spacecraft as a prerequisite to analysis of the data by the individual mission reaearch projects.

Major computational capabilities include the multi-mission Flight Dynamics Facility (FDF), which performs the real-time attitude, orbit, flight maneuver control and ground networks functions. The FDF workload has and will continue to steadily increase as the computational requirements of newly launched spacecraft add to the pre-existing workload of servicing satellites already in orbit. To handle the pending FDF over subscription, a two-phased solution has been put in place. In late 1992, the aged, overloaded FDF computer was replaced with a higher power software compatible computer system. We have also embarked on the migration to a future distributed computing architecture to further increase the capacity and to minimize life cycle cost. Other activities within this program include an engineering capability used to develop and test advanced data system components. Through these facilities, advanced techniques in the areas of remote payload operation and control, expert systems, high-speed data processing, high-level languages, and custom-engineered hardware processors using Very Large Scale Integration (VLSI) will be applied to operational systems to replace costly conventional architectures and reduce operational staffing needs.

In addition, there are four major systems for processing spacecraft data: (1) the Generic Time Division Multiplexer (GTDM) Facility, which processes data from all TDM satellites; (2) the Packet Data Processor (PACOR), which processes data from satellites that employ the new packet technology and protocols; (3) the Hubble Space Telescope Data Capture Facility (HSTDCF), which captures, processes, and forwards the packetized telemetry from the HST to the Science Institute Facility; and (4) the Spacelab Data Processing Facility (SLDPF), which performs the data processing required by Spacelab missions. The final success of the many missions depends on these data systems carrying out their required functions.

The large number of missions using modern packet data systems require corresponding packet data processing services. These missions include the SMEX series, SOHO, Cluster, and others. The existing PACOR capacity must be expanded to provide the required increased data processing capability in a cost-effective way, taking advantage of advances in distributed computing and VLSI digital processing. A laboratory, known as the Advanced On-board System (AOS) testbed, is being developed to evaluate advanced spacecraft data system components and the corresponding ground data handling and processing concepts to determine cost-effective ways to accomplish the high performance requirements of the future.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The increase of $0.7 million includes $0.2 million transferred from the ROS account plus $0.5 million for the HSTDCF software conversion to the extended PACOR system. With the conversion of the HSTDCF software to the multi-mission PACOR system, it will be possible to discontinue the operation of the stand alone HSTDCF, resulting in future cost savings.

BASIS OF FY 1994 ESTIMATE

The FY 1994 budget request will provide continued funding for improvements in the existing computation capabilities at GSFC that provide services to NASA spacecraft. The budget request includes funds to develop additional packet data processing capacity needed first by SOHO and also by later missions under development. In addition, the AOS testbed activity is continued. Funds are also requested for upgrading the data processing capabilities at GSFC to facilitate the exchange of data within the data processing complex and to other mission service facilities.

The budget request includes funding for equipment to provide the required reliability and availability of the FDF consistent with commitments to ongoing missions, new mission initiatives, and internal services to the space and ground networks, along with the acquisition of some elements of the future distributed architecture systems. The budget request also includes funding for the Data Systems Technology program to maintain the Very Large Scale Integration (VLSI) capability developed over several years and to apply state-of-the-art technologies to prototype system solutions.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Data processing operations.....	61,700	68,700	67,174	86,700

OBJECTIVES AND STATUS

Information received in the form of tracking and telemetry data from the various spacecraft must be processed into a usable form prior to analysis by the scientific investigation teams. This transformation is performed as part of the data processing function and applies to a wide variety of missions, ranging from the small explorer satellites to more complex imaging satellites.

Telemetry data is the primary product of spacecraft, and the mission objectives are achieved through analysis of this data by the investigators. Within the data processing program, data are processed to separate the information obtained from various scientific experiments aboard the spacecraft, to consolidate information for each experimenter, to determine spacecraft attitude, and to correlate these measurements with time and spacecraft position data.

The management, maintenance, operations, application software development, and software maintenance are performed for the major data processing and flight dynamics facilities. The FDF provides standard attitude products and services for the NASA low Earth-orbital spacecraft in all phases of the mission and orbit and Space Network computation services to a wide range of customers including the Shuttle. Pre-mission analysis is performed to define the flight plans and to specify the Flight Dynamics software that must be developed to monitor and verify the spacecraft attitude control system. The software is developed and operated throughout the life of the missions to ensure the health and safety of the spacecraft.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The decrease of $1.5 million reflects a $0.7 million increase due to the transfer from the ROS account along with $2.2 million of reductions made in operations and maintenance in the Spacelab Data Processing Facility.

BASIS OF FY 1994 ESTIMATE

The FY 1994 budget request provides for operation of the computational and data processing facilities: SLDPF, GTDM, PACOR, HSTDF, FDF, STL, and the AOS testbed. Included in the facilities operation are computer operations and maintenance, rentals and lease of proprietary products, small logistics, management and control of the facility resources, and facility user assistance.

The SLDPF funding provides hardware and software services the to Spacelab and Attached Shuttle Payloads. Pre-mission, mission, and post-mission activities are funded in FY 1994 for the launches of United States Microgracity Payload (USMP) -2, Office of Aeronautics and Space Technology (OAST) -2, Robotic Materials Processing System (ROMPS) -1, International Extreme-UV Far-UV (IEH) -1, and the International Microgravity Laboratory (IML) -2. In addition, preparation for missions to be launched in FY 1995, such as USMP-3, Astro-2, OAST-3, Candidate Materials Space Exposure (CMSE), and IEH-2 are also funded.

The budget request includes ongoing spacecraft services for HST, ICE, ERBS, IMP, IUE, SAMPEX, Compton Gamma Ray Observatory, UARS, Wind, EUVE, and STS Spacelab and other attached payload missions to develop the software enhancements and maintenance necessary to perform spacecraft attitude determination, attitude control and maneuver computations, and data processing. The request also includes new responsibilities for operational support for orbit determination, orbit control and maneuver computations, and network support for manned and unmanned missions.

Pre-mission analysis and planning to produce requirements, specifications, application software, prototyping, and system testing are also funded for the upcoming science and applications missions of Polar, SOHO, XTE, TOMS, FAST, SWAS, TRMM, EOS-AM-1, and ACE.

FISCAL YEAR
1994

BUDGET ESTIMATES

VOLUME II

CONSTRUCTION
OF FACILITIES

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
CONSTRUCTION OF FACILITIES
FISCAL YEAR 1994 ESTIMATES

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
FISCAL YEAR 1994 BUDGET ESTIMATES
CONSTRUCTION OF FACILITIES
GENERAL STATEMENT

The Construction of Facilities (CoF) appropriation provides contractual services for the repair, rehabilitation, and modification of existing facilities; the construction of new facilities and the acquisition of related collateral equipment; the acquisition or condemnation of real property; environmental compliance and restoration activities; the design of facilities projects; and advanced planning related to future facilities needs.

The funds requested for FY 1994 provide for continuing prior year endeavors to meet facilities requirements for the Advanced Solid Rocket Motor Program, and the modernization of the Ames Unitary Plan Wind Tunnel Complex; construction of additional facilities for the Earth Observing System (EOS) Program at Goddard Space Flight Center and Langley Research Center; construction of a 34-meter antenna at Goldstone, California, to start the second 34-meter beam waveguide subnet needed to support the mission set in the late 1990's; repair, rehabilitation, and modification of other facilities to restore, upgrade, and improve the usefulness of the NASA physical plant; minor construction of new facilities, facility planning and design activities; and environmental compliance and restoration. Also included is funding to continue the National Aeronautics Facilities Upgrade Program to improve the United States' aeronautics facilities capability so that we can enhance our competitive advantage in world aeronautics markets. This effort was initiated with $25 million provided by the Congress in FY 1993 for the high speed civil transport initiative and augmented by the new technology investment package.

The projects and amounts in the budget estimates reflect EOS, Space Communications, and Space Flight facilities requirements that are time-sensitive to meet specific program objectives. Other program requirements for FY 1994 include projects to restore, upgrade, and modernize existing facilities which have reached or exceeded the end of their normal design life. These facilities are critical to the development and operation of space transportation systems, payloads, and launches as well as our aeronautical and aerospace testing capabilities to support military and private industry users. In addition to the National Aeronautics Facilities Upgrade Program, projects to restore and/or upgrade heating, cooling, communication, control, and electrical distribution systems at Ames, Goddard, Jet Propulsion Laboratory, Johnson Space Center, Kennedy Space Center, Marshall Space Flight Center, Michoud Assembly Facility, and Stennis Space Center are included. Also included are

projects at Kennedy to upgrade the Firex systems at Launch Complexes 39A and 39B to provide the proper pressure classifications and to rehabilitate the fire alarm system in the Industrial Area. Projects at Marshall and Stennis restore high pressure air and gas capacity and high pressure industrial water systems to critical testing facilities. The National Full-Scale Aerodynamic Complex at Ames will be upgraded to increase testing capabilities and the deteriorated Rocket Engine Test Facility at Lewis Research Center will be rehabilitated and modernized to improve reliability and productivity in space propulsion technology programs testing through decreased downtime for breakdowns and maintenance. The airfield at Wallops will be restored and Kennedy's Class III landfill capacity will be restored to accommodate the disposal of non-hazardous debris.

The FY 1994 program continues to meet the objectives of preserving and enhancing the capabilities and usefulness of existing facilities and ensuring safe, economical, and efficient use of the NASA physical plant. This request continues the necessary rehabilitation and modification program begun in prior years and continues a responsive repair program. The repair program restores facilities to a condition substantially equivalent to their originally designed capability. The minor construction program continues to provide a means to accomplish smaller facility projects which accommodate changes in technical and institutional requirements. The environmental compliance and restoration program ensures that statutory environmental requirements are met and any necessary remedial actions are promptly taken.

Funds requested for facility planning and design cover advance planning and design requirements for potential future projects, master planning, facilities studies, engineering reports and studies, and the preparation of facility project design drawings and bid specifications.

The budget authority requested for FY 1994 is $545,300,000, with estimated outlays of $540,197,000.

PROPOSED APPROPRIATION LANGUAGE

Construction of Facilities

For construction, repair, rehabilitation and modification of facilities, minor construction of new facilities and additions to existing facilities, and for facility planning and design not otherwise provided, for the National Aeronautics and Space Administration, and for the acquisition or condemnation of real property, as authorized by law, [$525,000,000] *$545,500,000* to remain available until September 30, [1995] *1996*: *Provided*, That, notwithstanding the limitation on the availability of funds appropriated under this heading by this appropriations Act, when any activity has been initiated by the incurrence of obligations therefor, the amount available for such activity shall remain available until expended, except that this provision shall not apply to the amounts appropriated pursuant to the authorization for repair, rehabilitation and modification of facilities, minor construction of new facilities and additions to existing facilities, and facility planning and design: *Provided further*, That no amount appropriated pursuant to this or any other Act may be used for the lease or construction of a new contractor-funded facility for exclusive use in support of a contract or contracts with the National Aeronautics and Space Administration under which the Administration would be required to substantially amortize through payment or reimbursement such contractor investment, unless an appropriations Act specifies the lease or contract pursuant to which such facilities are to be constructed or leased or such facility is otherwise identified in such Act: *Provided further*, That the Administrator may authorize such facility lease or construction, if he determines, in consultation with the Committees on Appropriations, that deferral of such action until the enactment of the next appropriations Act would be inconsistent with the interest of the Nation in aeronautical and space activities. *(Departments of Veterans Affairs and Housing and Urban Development, and Independent Agencies Appropriations Act, 1993.)*

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
CONSTRUCTION OF FACILITIES
FISCAL YEAR 1994 ESTIMATES

SUMMARY OF THE BUDGET PLAN BY LOCATION
(Thousands of Dollars)

LOCATION	Fiscal Year 1992	Fiscal Year 1993	Fiscal Year 1994 Agency Request
Space Station Freedom Facilities	35,000	13,800	---
Space Flight Facilities	168,120	193,400	88,000
Lyndon B. Johnson Space Center	7,000	4,000	2,200
John F. Kennedy Space Center	6,700	---	1,900
George C. Marshall Space Flight Center	5,200	---	2,600
John C. Stennis Space Center	---	2,200	3,800
Goddard Space Flight Center	23,500	19,800	25,600
Jet Propulsion Laboratory	5,500	---	2,900
Wallops Flight Facility	3,500	---	5,200
Aeronautical Facilities at Various Facilities	48,300	64,800	212,000
Langley Research Center	---	---	8,000
Lewis Research Center	---	---	12,500
Various Locations	10,600	33,800	17,600
Repair	31,700	31,900	36,000
Rehabilitation and Modification	34,800	34,000	36,000
Minor Construction	12,900	14,000	14,000
Facility Planning and Design	27,880	23,300	27,000
Delta College	---	8,000	---
Deferred Rehabilitation and Major Maintenance	11,800	---	---
Classroom of the Future	6,000	---	---
Consortium for International Earth Science Information Network (CIESIN)	3,400	42,000	---
National Technology Transfer Center	13,500	---	---
Christopher Columbus Center of Marine Research and Exploration	20,000	---	---
Independent Software Validation and Verification Facility	10,000	---	---
Space Dynamics Laboratory	10,000	---	---
Environmental Compliance and Restoration	36,000	40,000	50,000
Total Plan	531,400	525,000	545,300

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
CONSTRUCTION OF FACILITIES
FISCAL YEAR 1994 ESTIMATES

SUMMARY OF THE BUDGET PLAN BY COGNIZANT OFFICE
(Thousands of Dollars)

OFFICE	Fiscal Year 1992	Fiscal Year 1993	Fiscal Year 1994 Agency Request
Space Systems Development	45,000	13,800	---
Space Flight	181,820	199,600	98,500
Space Science	22,200	2,000	2,900
Mission To Planet Earth	33,800	61,800	38,800
Aeronautics	48,300	64,800	212,000
Advanced Concepts and Technology	13,500	---	12,500
Human Resources and Education	6,000	8,000	---
Space Communications	5,700	31,800	17,600
Management Systems and Facilities	175,080	143,200	163,000
Total Plan	531,400	525,000	545,300

SUMMARY OF THE BUDGET PLAN BY SUBFUNCTION
(Thousands of Dollars)

Code				
252	Space Flight, Research, and Supporting Activites	483,100	460,200	333,300
402	Air Transportation	48,300	64,800	212,000
	Total Plan	531,400	525,000	545,300

CONSTRUCTION OF FACILITIES
FISCAL YEAR 1994 ESTIMATES
BUDGET PLAN BY LOCATION AND PROJECT

(Thousands of Dollars)

CO	BA	SF	INSTALLATION AND PROJECT	Fiscal Year 1992	Fiscal Year 1993	Fiscal Year 1994 Agency Request	Page No.
			SPACE STATION FREEDOM FACILITIES AT VARIOUS LOCATIONS:	35,000	13,800	---	
SSD	1	252	Construction of Space Station Processing Facility (KSC)	35,000	12,000	---	
SSD	1	252	Modifications for Payload Operations Integration Center (MSFC)	---	1,800	---	
			SPACE FLIGHT FACILITIES AT VARIOUS LOCATIONS:	168,120	193,400	88,000	
SF	1	252	Replace Mission Control Center Air Handlers (JSC)	---	---	8,000	CF 1-1
SF	1	252	Replace Thermal Vacuum Helium Refrigeration Systems (JSC)	---	---	7,400	CF 1-5
SF	1	252	Modify Launch Complex 39 Exterior Utility Piping (KSC)	---	---	1,200	CF 1-10
SF	1	252	Refurbish Launch Complex 39 Cooling System (KSC)	---	---	4,000	CF 1-13
SF	1	252	Refurbish Launch Complex 39 Secondary Circuit Breakers (KSC)	---	---	3,300	CF 1-16
SF	1	252	Refurbish Vehicle Assembly Building/Pad Water Storage Tanks (KSC)	---	---	3,000	CF 1-19
SF	1	252	Rehabilitate Industrial Area Fire Alarm Reporting System (KSC)	---	---	4,900	CF 1-22
SF	1	252	Restore C-5 Substation, Launch Complex 39 Area (KSC)	---	---	5,000	CF 1-25
SF	1	252	Restoration of High Pressure Air Compressor System (MSFC)	---	---	8,500	CF 1-28
SF	1	252	Repair Decking and Roof, X-Ray and Staging Facility (MAF)	---	---	1,500	CF 1-31
SF	1	252	Replace Cooling Tower and Boiler (MAF)	---	---	4,000	CF 1-34
SF	1	252	Restore SSME Test Complex High Pressure Industrial Water System (SSC)	---	---	2,300	CF 1-38
SF	1	252	Replace Aircraft Operations Support Facilities (JSC)	---	1,600	---	
SF	1	252	Modify Electrical and Mechanical Systems, Utility Annex (KSC)	---	4,400	---	
SF	1	252	Rehabilitate Explosive Safe Area-60 High Bays Support Systems (KSC)	---	2,000	---	
SF	1	252	Rehabilitate LC-39 Area Fire Alarm Reporting System (KSC)	---	4,300	---	
SF	1	252	Replace Boiler House Components (MAF)	---	2,300	---	
SF	1	252	Restoration of Information and Electronic Systems Laboratory (MSFC)	---	5,000	---	
SF	1	252	Restore High Pressure Gas Storage Capacity (SSC)	---	6,800	2,300	CF 1-41
SF	1	252	Construction of Addition for Flight Training and Operations (JSC)	8,000	---	---	
SF	1	252	Modification for Earthquake Protection, Downey, CA (JSC)	4,400	---	---	
SF	1	252	Rehabilitation of Crawlerway (KSC)	3,000	2,000	---	
SF	1	252	Restoration of Shuttle Landing Facility Shoulders (KSC)	2,720	---	---	
SF	1	252	Construction of Advanced Solid Rocket Motor Program Facilities (Various Locations)	150,000	165,000	32,600	CF 1-44 SUM 6

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
CONSTRUCTION OF FACILITIES
FISCAL YEAR 1994 ESTIMATES
BUDGET PLAN BY LOCATION AND PROJECT

(Thousands of Dollars)

CO	BA	SF	INSTALLATION AND PROJECT	Fiscal Year 1992	Fiscal Year 1993	Fiscal Year 1994 Agency Request	Page No.
			LYNDON B. JOHNSON SPACE CENTER	7,000	4,000	2,200	
SF	7	252	Rehabilitate Electrical Distribution System, Project Management Building	---	---	2,200	CF 2-1
SF	7	252	Repair Site Water System, White Sands Test Facility	1,300	---	---	
SF	7	252	Replace Central Plant Chilled Water Equipment	5,700	4,000	---	
			JOHN F. KENNEDY SPACE CENTER	6,700	---	1,900	
SF	7	252	Restore Class III Landfill	---	---	1,900	CF 3-1
SF	7	252	Rehabilitation and Expansion of Communications Duct Banks	1,400	---	---	
SF	7	252	Modernization of Industrial Area Chilled Water System	4,000	---	---	
SF	7	252	Replace 15 KV Load Break Switches	1,300	---	---	
			MARSHALL SPACE FLIGHT CENTER	5,200	---	2,600	
SF	7	252	Restoration of Electrical Power System	---	---	2,600	CF 4-1
SS	2	252	Modifications to X-Ray Calibration Facility (XRCF)	5,200	---	---	
			JOHN C. STENNIS SPACE CENTER	---	2,200	3,800	
SF	7	252	Restoration of Underground Communication Distribution System	---	2,200	3,800	CF 5-1
			GODDARD SPACE FLIGHT CENTER	23,500	19,800	25,600	
MTPE	3	252	Construction of Earth Systems Science Building	---	---	12,000	CF 6-1
MTPE	7	252	Replacement of Central Plant Steam and Electrical Generation Equipment	---	---	8,600	CF 6-5
MTPE	7	252	Restoration and Modernization of Chilled Water System	---	---	5,000	CF 6-11
MTPE	7	252	Restoration/Modernization of Electrical Distribution System	---	4,500	---	
MTPE	7	252	Restoration and Modernization of High Voltage Distribution System	5,000	---	---	
MTPE	3	252	Construction of Earth Observing System Data Information System (EOSDIS) Facility	17,000	15,300	---	
SS	2	252	Construct Additional Support Facilities in Spacecraft Systems Development/Integration Facility	1,500	---	---	

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
CONSTRUCTION OF FACILITIES
FISCAL YEAR 1994 ESTIMATES
BUDGET PLAN BY LOCATION AND PROJECT

(Thousands of Dollars)

CO	BA	SF	INSTALLATION AND PROJECT	Fiscal Year 1992	Fiscal Year 1993	Fiscal Year 1994 Agency Request	Page No.
			JET PROPULSION LABORATORY	5,500	---	2,900	
SS	7	252	Modifications to Cooling Systems, Various Buildings	---	---	2,900	CF 7-1
SS	7	252	Modernization of Main Electrical Substation	5,500	---	---	
			WALLOPS FLIGHT FACILITY	3,500	---	5,200	
MTPE	7	252	Restoration of Airfield	---	---	5,200	CF 8-1
MTPE	7	252	Restoration of Utilities	3,500	---	---	
			AERONAUTICAL FACILITIES AT VARIOUS LOCATIONS:	48,300	64,800	212,000	
A	5	402	National Aeronautics Facilities Upgrade Program (Various Locations)	---	25,000	181,000	CF 9A-1
			Aeronautical Facilities Revitalization	48,300	39,800	31,000	
A	5	402	Rehabilitation of Control Systems, National Full-Scale Aerodynamics Complex (ARC)	---	---	(2,100)	CF 9B-1
A	5	402	Upgrade of Outdoor Aerodynamic Research Facility (ARC)	---	---	(3,900)	CF 9B-6
A	5	402	Modernization of the Unitary Plan Wind Tunnel Complex (ARC)	---	(8,000)	(25,000)	CF 9B-11
A	5	402	Modernization of 16-Foot Transonic Tunnel (LaRC)	(3,400)	---	---	
A	5	402	Modifications to 14 by 22-Foot Subsonic Wind Tunnel (LaRC)	---	(2,200)	---	
A	5	402	Rehabilitation of Icing Research Tunnel (LeRC)	(2,600)	---	---	
A	5	402	Repair and Modernization of the 12-Foot Pressure Wind Tunnel (ARC)	(25,000)	(17,400)	---	
A	5	402	Modifications to the High Pressure Air System (LaRC)	(11,700)	---	---	
A	5	402	Rehabilitation of Central Air System (LeRC)	(5,600)	(12,200)	---	
			LANGLEY RESEARCH CENTER	---	---	8,000	
MTPE	3	252	Construction of EOSDIS Distributed Active Archive Center (DAAC)	---	---	8,000	CF 10-1

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
CONSTRUCTION OF FACILITIES
FISCAL YEAR 1994 ESTIMATES
BUDGET PLAN BY LOCATION AND PROJECT

(Thousands of Dollars)

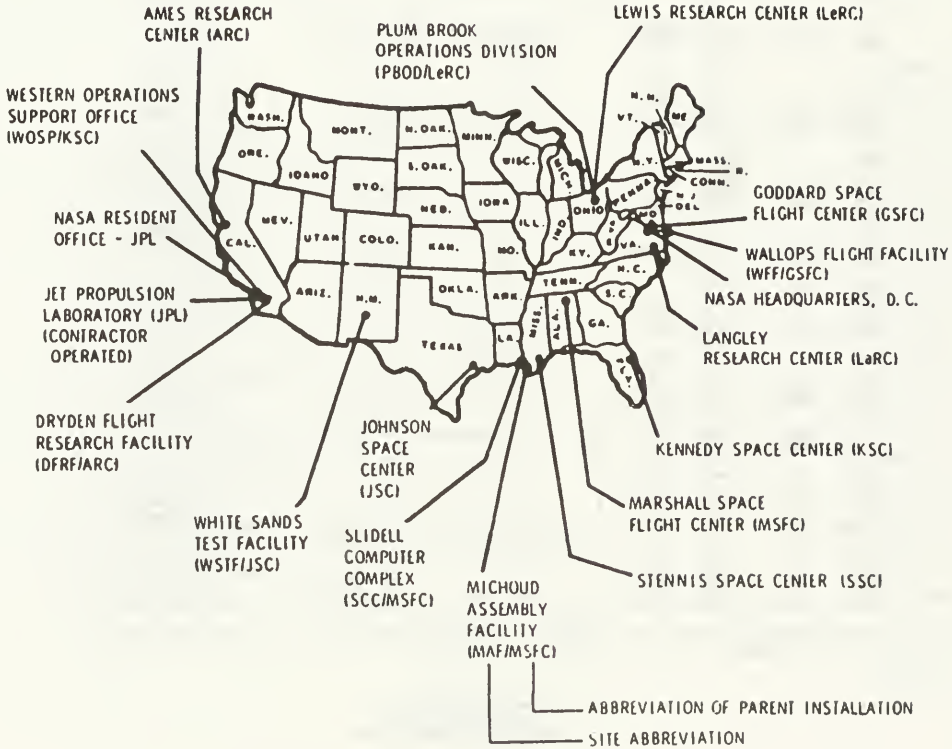
CO	BA	SP	INSTALLATION AND PROJECT	Fiscal Year 1992	Fiscal Year 1993	Fiscal Year 1994 Agency Request	Page No.
			LEWIS RESEARCH CENTER	---	---	12,500	
ACT	4	252	Rehabilitation of Rocket Engine Test Facility	---	---	12,500	CF 11-1
			VARIOUS LOCATIONS	10,600	33,800	17,600	
SC	7	252	Construction of 34-Meter Multifrequency Antenna, Goldstone (JPL)	---	---	17,600	CF 12-1
SC	7	252	Construction of 34-Meter Multifrequency Antenna, Canberra, Australia (JPL)	---	15,600	---	
SC	7	252	Construction of 34-Meter Multifrequency Antenna, Madrid, Spain (JPL)	---	16,200	---	
SS	2	252	Restoration and Modernization of Infrared Telescope Facility Mauna Kea, HI	---	2,000	---	
SC	7	252	Rehabilitation of Tracking and Data Relay Satellite System (TDRSS) Ground Terminal, White Sands Test Facility, NM	5,700	---	---	
MTPE	3	252	Construct Data Interface Facility, VSTF	4,900	---	---	
MSF	7	252	REPAIR OF FACILITIES AT VARIOUS LOCATIONS, NOT IN EXCESS OF $1,000,000 PER PROJECT	31,700	31,900	36,000	CF 13-1
MSF	7	252	REHABILITATION AND MODIFICATION OF FACILITIES AT VARIOUS LOCATIONS NOT IN EXCESS OF $1,000,000 PER PROJECT	34,800	34,000	36,000	CF 14-1
MSF	7	252	MINOR CONSTRUCTION OF NEW FACILITIES AND ADDITIONS TO EXISTING FACILITIES AT VARIOUS LOCATIONS, NOT IN EXCESS OF $750,000 PER PROJECT	12,900	14,000	14,000	CF 15-1
MSF	7	252	FACILITY PLANNING AND DESIGN	27,880	23,300	27,000	CF 16-1

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
CONSTRUCTION OF FACILITIES
FISCAL YEAR 1994 ESTIMATES
BUDGET PLAN BY LOCATION AND PROJECT

(Thousands of Dollars)

CO	BA	SF	INSTALLATION AND PROJECT	Fiscal Year 1992	Fiscal Year 1993	Fiscal Year 1994 Agency Request	Page No.
HRE	3	252	DELTA COLLEGE	---	8,000	---	
MSF	7	252	DEFERRED REHABILITATION AND MAJOR MAINTENANCE	11,800	---	---	
HRE	3	252	CLASSROOM OF THE FUTURE	6,000	---	---	
MTPE	3	252	CONSORTIUM FOR INTERNATIONAL EARTH SCIENCE INFORMATION NETWORK (CIESIN)	3,400	42,000	---	
ACT	3	252	NATIONAL TECHNOLOGY TRANSFER CENTER	13,500	---	---	
MSF	7	252	CHRISTOPHER COLUMBUS CENTER OF MARINE RESEARCH AND EXPLORATION	20,000	---	---	
SSD	1	252	INDEPENDENT SOFTWARE VALIDATION AND VERIFICATION FACILITY	10,000	---	---	
SS	2	252	SPACE DYNAMICS LABORATORY	10,000	---	---	
			S U B T O T A L , CONSTRUCTION	495,400	485,000	495,300	
MSF	7	252	ENVIRONMENTAL COMPLIANCE AND RESTORATION PROGRAM	36,000	40,000	50,000	CF 17-1
			T O T A L , CONSTRUCTION OF FACILITIES	531,400	525,000	545,300	

LOCATION OF MAJOR AND COMPONENT INSTALLATIONS



SUM 11

RECORDED VALUE OF CAPITAL TYPE PROPERTY
IN-HOUSE AND CONTRACTOR-HELD
AS OF SEPTEMBER 30, 1992
(DOLLARS IN THOUSANDS)

REPORTING INSTALLATION	LAND	BUILDING	OTHER STRUCTURES AND FACILITIES	LEASEHOLD IMPROVEMENTS	TOTAL	EQUIPMENT	FIXED ASSETS IN PROGRESS	GRAND TOTAL
AMES RESEARCH CENTER	2,929	574,152	39,700	0	616,781	417,041	231,434	1,265,256
ARC MOFFETT FIELD, CA	2,928	517,404	18,601	0	538,933	318,304	221,979	1,079,216
DRYDEN FLIGHT FACILITY EDWARDS, CA	0	56,052	20,752	0	76,804	94,050	9,455	180,309
VARIOUS LOCATIONS	1	698	347	0	1,044	4,687	0	5,731
GODDARD SPACE FLIGHT CENTER	3,098	267,094	128,470	11	398,671	570,252	73,987	1,042,910
GSFC-GREENBELT, MD	1,577	174,288	25,185	0	201,050	282,437	39,392	522,879
TRACKING STATIONS NETWORK	5	38,663	23,153	0	61,841	102,865	19,323	184,049
WFF-WALLOPS ISLAND, VA	1,514	53,172	75,923	0	130,609	71,025	15,272	216,906
VARIOUS LOCATIONS	0	951	4,209	11	5,171	113,905	0	119,076
JET PROPULSION LABORATORY	1,188	180,830	114,333	1,098	297,247	373,403	58,186	728,836
JPL PASADENA, CA	1,188	180,630	114,333	1,098	297,247	373,403	58,186	728,836
JOHNSON SPACE CENTER	11,236	297,914	105,789	105	415,026	670,691	26,223	1,112,140
JSC-HOUSTON, TX	7,291	248,781	69,575	0	325,647	423,542	26,223	775,412
WHITE SANDS TEST FACILITY LOS CRUCES, NM	377	14,909	30,331	105	45,722	26,901	0	72,623
VARIOUS LOCATIONS	3,570	34,224	5,863	0	43,657	220,448	0	264,105
KENNEDY SPACE CENTER	71,345	601,650	535,505	0	1,208,500	4,598,904	103,818	5,909,222
KSC-CAPE CANAVERAL, FL	71,345	601,650	535,505	0	1,208,500	3,837,632	103,818	5,149,950
WESTERN TEST RANGE, LOMPAC, CA	0	0	0	0	0	2,729	0	2,729
VARIOUS LOCATIONS	0	0	0	0	0	756,543	0	756,543
LANGLEY RESEARCH CENTER	156	226,670	438,879	0	665,705	305,673	42,661	1,014,039
LARC-HAMPTON, VA	156	226,670	438,879	0	665,705	290,441	42,661	998,807
VARIOUS LOCATIONS	0	0	0	0	0	15,232	0	15,232
LEWIS RESEARCH CENTER	2,621	291,986	110,702	136	405,445	246,020	58,549	710,014
LERC-CLEVELAND, OH	316	214,836	91,493	136	306,781	153,642	58,549	518,972
PLUMBROOK, SANDUSKY, OH	2,305	77,150	19,062	0	98,517	79,693	0	178,210
VARIOUS LOCATIONS	0	0	147	0	147	12,685	0	12,832
MARSHALL SPACE FLIGHT CENTER	11,093	342,013	198,621	0	551,727	783,945	10,218	1,345,890
MSFC-HUNTSVILLE, AL	0	168,562	98,205	0	266,767	421,797	10,218	698,782
MICHOUD ASSEMBLY FACILITY, LA	7,162	161,909	86,654	0	255,725	73,791	0	329,516
SLIDELL COMPUTER COMPLEX, LA	69	5,253	3,155	0	8,477	15,204	0	23,681
VARIOUS LOCATIONS	3,862	6,289	10,607	0	20,758	273,153	0	293,911
STENNIS SPACE CENTER	18,061	117,922	233,016	0	368,999	40,378	29,715	439,092
STENNIS SPACE CENTER	18,061	117,922	233,016	0	368,999	40,378	29,715	439,092
VARIOUS LOCATIONS	0	0	0	0	0	0	0	0
NASA HEADQUARTERS	0	0	0	0	0	65,301	0	65,301
NASA-HQS, WASH, DC	0	0	0	0	0	42,195	0	42,195
VARIOUS LOCATIONS	0	0	0	0	0	23,105	0	23,105
AGENCY TOTAL	121,727	2,999,031	1,904,995	1,348	4,928,101	8,069,868	634,791	13,632,760

SUM 12

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
CONSTRUCTION OF FACILITIES
FISCAL YEAR 1994 ESTIMATES

SUMMARY

SPACE FLIGHT FACILITIES

	Amount (Dollars)	Page No.
Space Flight:		
Replace Mission Control Center Air Handlers, Johnson Space Center	8,000,000	CF 1-1
Replace Thermal Vacuum Helium Refrigeration Systems, Johnson Space Center	7,400,000	CF 1-5
Modidify Launch Complex 39 Exterior Utility Piping, Kennedy Space Center	1,200,000	CF 1-10
Refurbish Launch Complex 39 Cooling System, Kennedy Space Center	4,000,000	CF 1-13
Refurbish Launch Complex 39 Secondary Circuit Breakers, Kennedy Space Center	3,300,000	CF 1-16
Refurbish Vehicle Assembly Building/Pad Water Storage Tanks, Kennedy Space Center	3,000,000	CF 1-19
Rehabilitate Industrial Area Fire Alarm Reporting System, Kennedy Space Center	4,900,000	CF 1-22
Restore C-5 Substation, Launch Complex 39 Area, Kennedy Space Center	5,000,000	CF 1-25
Restoration of High Pressure Air Compressor System, Marshall Space Flight Center	8,500,000	CF 1-28
Repair Decking and Roof, X-Ray and Staging Facility, Michoud Assembly Facility	1,500,000	CF 1-31
Replace Cooling Tower and Boiler, Michoud Assembly Facility	4,000,000	CF 1-34
Restore SSME Test Complex High Pressure Industrial Water System, Stennis Space Center	2,300,000	CF 1-38
Restore High Pressure Gas Storage Capacity, Stennis Space Center	2,300,000	CF 1-41
Construction of Advanced Solid Rocket Motor Program Facilities, Various Locations	32,600,000	CF 1-44
Total	88,000,000	

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1994 ESTIMATES

PROJECT TITLE: Replace Mission Control Center Air Handlers

INSTALLATION: Lyndon B. Johnson Space Center

FY 1994 CoF ESTIMATE: $8,000,000

LOCATION OF PROJECT: Houston, Harris County, Texas

COGNIZANT HEADQUARTERS OFFICE: Office of Space Flight

FY 1993 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF Funding	$720,000	---	$ 720,000
Capitalized Investment	---	$34,237,572	34,237,572
Total	$720,000	$34,237,572	$34,957,572

SUMMARY PURPOSE AND SCOPE:

This project provides for the conversion to an energy saving variable air volume system by replacing six large built-up air handlers and associated components in the Mission Control Center, Building 30. Also included will be a 140-foot by 28-foot extension on the north end of the building to house the new air handlers.

PROJECT JUSTIFICATION:

The air handling system is approaching the end of its original design life and deteriorated to a condition that likely could adversely impact on Space Shuttle mission support. There are already internal leaks in the chilled water coil bundles and repairs cannot be made due to time and work

space constraints. The structural integrity of the units is failing due to constant exposure to moisture and must be replaced.

IMPACT OF DELAY:

The capability to provide continued cooling to the Mission Control Center may be impaired if this project is delayed. The worst case failure would be loss of cooling to the computer systems, effectively shutting down the Mission Control Center.

PROJECT DESCRIPTION:

This project provides for the replacement of six large built-up air-handlers supplying overhead air to all three floors of the Mission Control Center, a 140- by 28-foot three-story mechanical equipment addition to the north of the building, and replacement of approximately 150 mixing boxes with variable air volume boxes. The mechanical room addition is required to keep the present air handling units operational until the new units become operational. The existing air handling units will then be removed. Air ductwork revisions and installation of associated electrical and mechanical systems and controls needed to effect these replacements are included. The constant volume mixing boxes will be replaced with variable air volume boxes to redistribute the air flow and effect energy conservation. The project also includes the removal of asbestos spray-applied insulation and piping insulation as required. The main chilled water piping within the building mechanical rooms also will be revised as required.

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Cost
Construction:	---	---	---	$8,000,000
Demolition/Asbestos Abatement . . .	LS	---	---	197,000
Architectural/Structural Addition .	SF	11,760	125	1,470,100
Mechanical Air Handlers	EA	9	338,467	3,046,200
Mechanical VAV Boxes	EA	150	8,494	1,274,100
Mechanical Piping and Valves	LF	600	327	196,000
Mechanical Ductwork	LS	---	---	654,000
Mechanical Air Devices	EA	590	197	116,300
Electrical Modifications	LS	---	---	1,046,300
Total				$8,000,000

LIST OF RELATED GRAPHICS: Figure 1 - Site Location Plan

OTHER EQUIPMENT SUMMARY: None

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT: None

LYNDON B. JOHNSON SPACE CENTER
FISCAL YEAR 1994 ESTIMATES
REPLACE MISSION CONTROL CENTER AIR HANDLERS

SITE LOCATION PLAN

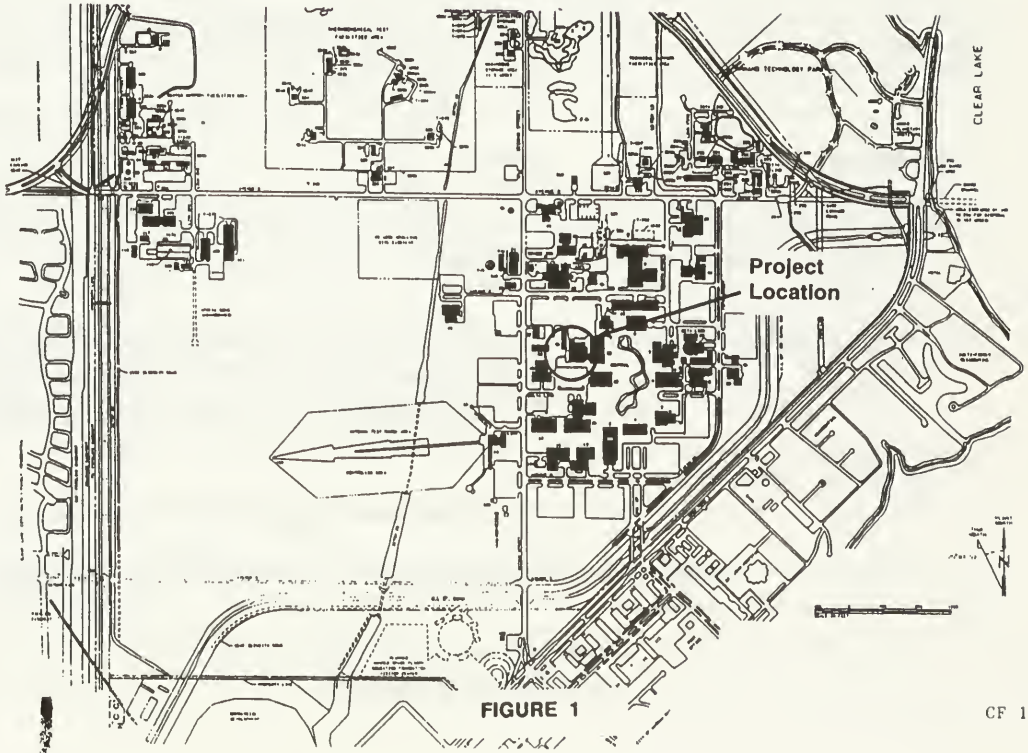


FIGURE 1

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1994 ESTIMATES

PROJECT TITLE: Replace Thermal Vacuum Helium Refrigeration Systems

INSTALLATION: Lyndon B. Johnson Space Center

FY 1994 CoF ESTIMATE: $7,400,000

LOCATION OF PROJECT: Houston, Harris County, Texas

COGNIZANT HEADQUARTERS OFFICE: Office of Space Flight

FY 1993 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF Funding	$457,000	---	$ 457,000
Capitalized Investment	---	$42,206,810	42,206,810
Total	$457,000	$42,206,810	$42,663,810

SUMMARY PURPOSE AND SCOPE:

This project provides for the replacement of five obsolete helium refrigerators with three new larger helium refrigerators in the Space Environment Simulation Laboratory, Building 32. This helium refrigeration system is essential for attaining and maintaining high-vacuum conditions for thermal vacuum testing of program-related test articles, devices, and systems.

PROJECT JUSTIFICATION:

This project is required to maintain and ensure reliable operations for vacuum Chambers A and B in the Space Environment Simulation Laboratory to support a number of satellite retrieval/repair and other thermal vacuum test projects. The existing helium refrigerators are at the end of their 30 year design life and unreliable, increasing the risk of failure and possible impact on program schedules. Replacement parts for the system are expensive and not readily available since many components have to be custom made. Significant operation and maintenance costs can be avoided once these new helium refrigerators are operational.

IMPACT OF DELAY:

The potential of major test compromises and delays will be significantly increased.

PROJECT DESCRIPTION:

Modifications include replacement of five obsolete 1.75-kW helium refrigerators with three new 3.5-kW helium refrigerators in the Space Environment Simulation Laboratory, Building 32. Two of the refrigerators will be located in a new 3,000 square foot cryogenics room adjecent to the existing Chamber A cryogenics room. The other refrigerator will be located in the existing cryogenics room near Chamber B. Necessary modifications to the facility's ventilation, electrical, chilled water, liquid nitrogen, and gaseous helium systems will be accomplished.

The project also provides for rehabilitation and automation of chamber support control systems including Chambers A and B vacuum roughing pump system, Chamber A liquid nitrogen shrouds, Chamber A lunar plain heater, and Chamber A helium cryogenics pumping shrouds. Automated monitoring and control of chamber systems will be installed and connected to an existing distributed process control system. Existing control systems are over 30 years old and have deteriorated to an undesirable and efficient level.

PROJECT COST ESTIMATE:	Unit of Measure	Quantity	Unit Cost	Cost
Construction:	---	---	---	$7,400,000
Sitework and Demolition	LS	---	---	45,700
Architectural/Structural	SF	3,000	102.57	307,700
Refrigerator Installation	EA	3	2,064,700	6,194,100
Piping Modifications	LS	---	---	215,600
Electrical Modifications	LS	---	---	136,900
Controls	LS	---	---	500,000
Total				$7,400,000

LIST OF RELATED GRAPHICS: Figure 1 - Isometric View Figure 2 - Systems Plan

OTHER EQUIPMENT SUMMARY: None

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT: None

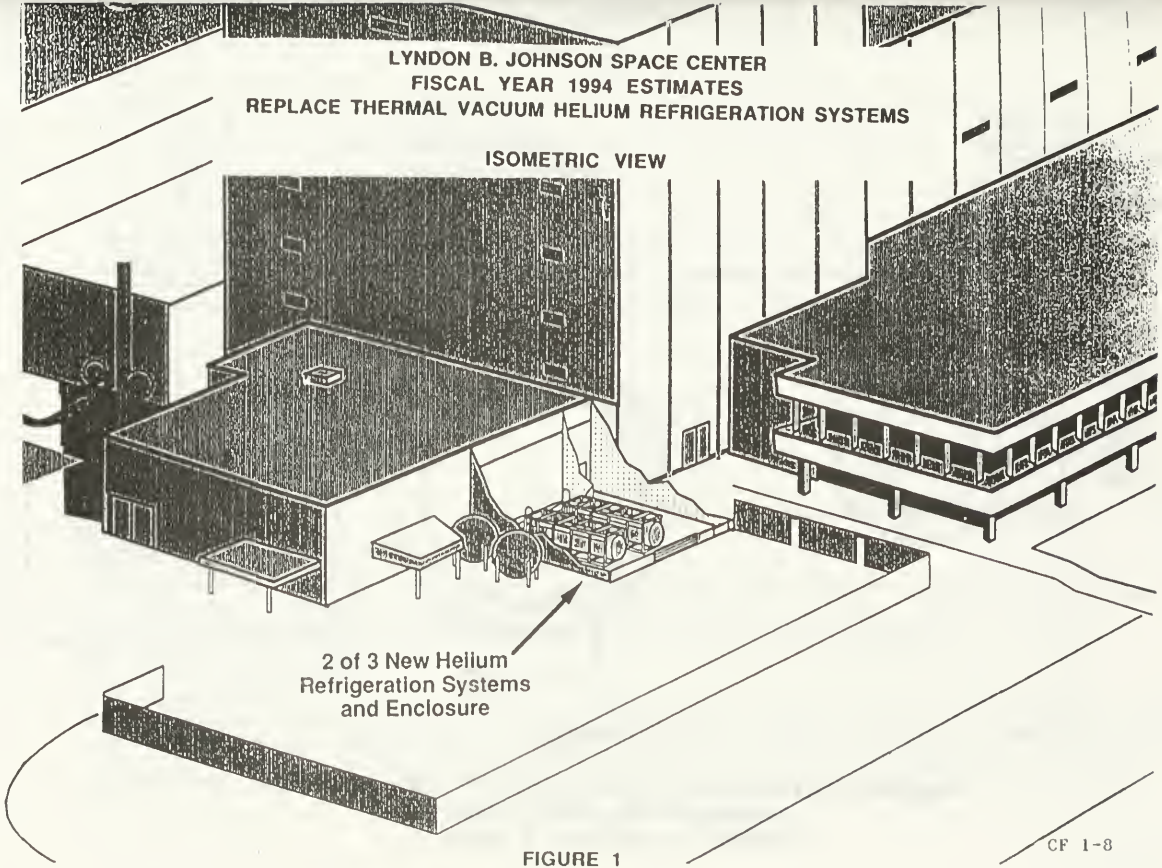

LYNDON B. JOHNSON SPACE CENTER
FISCAL YEAR 1994 ESTIMATES
REPLACE THERMAL VACUUM HELIUM REFRIGERATION SYSTEMS
ISOMETRIC VIEW
2 of 3 New Helium
Refrigeration Systems
and Enclosure
CF 1-8

FIGURE 1

LYNDON B. JOHNSON SPACE CENTER
FISCAL YEAR 1994 ESTIMATES
REPLACE THERMAL VACUUM HELIUM REFRIGERATION SYSTEMS

SYSTEMS PLAN

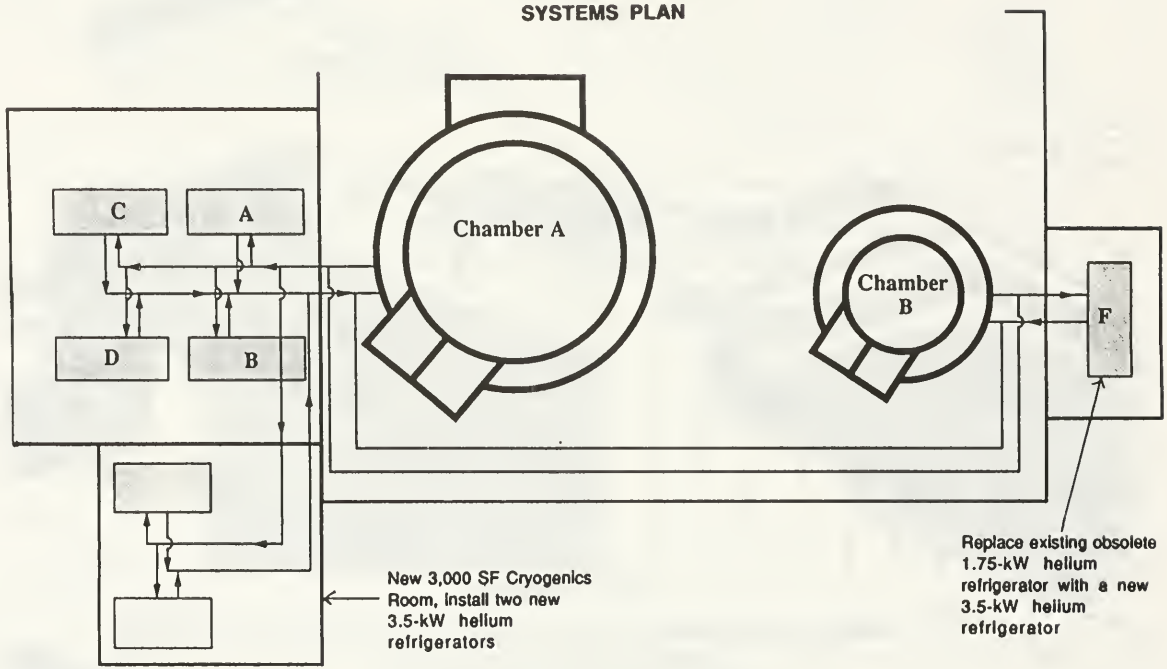


FIGURE 2

PROJECT TITLE: Modify Launch Complex 39 Exterior Utility Piping

INSTALLATION: John F. Kennedy Space Center

FY 1994 CoF Estimate: $1,200,000

LOCATION OF PROJECT: John F. Kennedy Space Center, Brevard County, Florida

COGNIZANT HEADQUARTERS OFFICE: Office of Space Flight

FY 1993 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF Funding	$122,000	---	$ 122,000
Capitalized Investment	---	$216,362,462	216,362,462
Total	$122,000	$216,362,462	$216,484,462

SUMMARY PURPOSE AND SCOPE:

This project provides for reconfiguring the High Temperature Hot Water (HTHW) expansion system, control valve replacement, generator pumping, and distribution piping in the LC-39 area to overcome an outdated heating system and permit an energy-efficient operation.

PROJECT JUSTIFICATION:

The existing HTHW system is 27 years old, inefficient, and does not provide control of the water temperature leaving the Utility Annex. The present system causes variations in temperature that could damage equipment which must be maintained at close tolerance. In addition, modifications of the control system included in this project will allow for balancing HTHW water flow with system loads optimizing energy efficiency.

IMPACT OF DELAY:

Failure to implement this project will result in continued inefficient operation of the HTHW distribution system in the launch control area, which risks equipment damage and/or disruption to launch processing activities.

PROJECT DESCRIPTION:

This project provides for replacement of compression tanks and piping between heat source and the heat load. A new stand-by pump and interconnecting piping will be provided along with replacement of all existing 3-way control valves with 2-way control valves at the heat exchangers. Additionally, asbestos abatement and reinsulation of some piping is required.

PROJECT COST ESTIMATE:	Unit of Measure	Quantity	Unit Cost	Cost
Construction:	---	---	---	$1,200,000
Asbestos Abatement	LS	---	---	400,000
New Tanks & Valves	LS	---	---	500,000
Generator Pump	LS	---	---	75,000
Piping	LS	---	---	225,000
Total				$1,200,000

LIST OF RELATED GRAPHICS: Figure 1 - Site Plan

OTHER EQUIPMENT SUMMARY: None

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT: None

JOHN F. KENNEDY SPACE CENTER
FISCAL YEAR 1994 ESTIMATES
MODIFY LAUNCH COMPLEX 39 EXTERIOR UTILITY PIPING

SITE PLAN

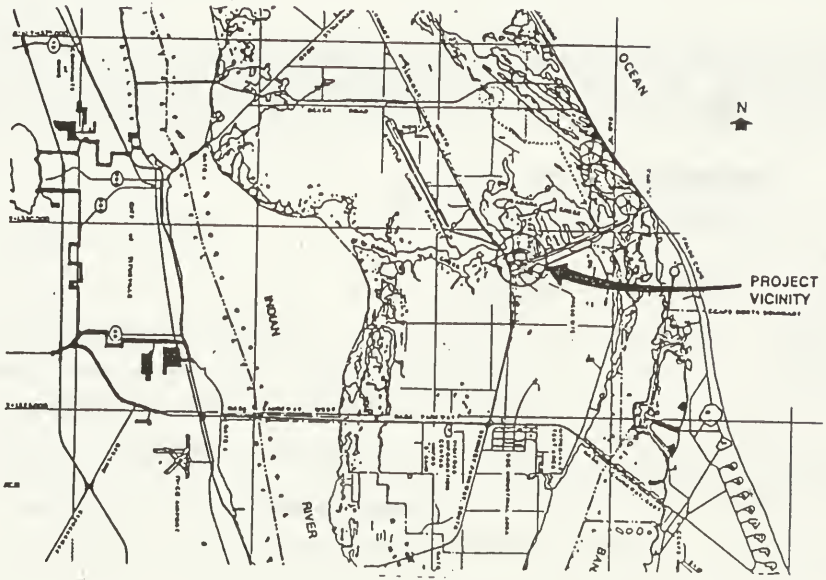


FIGURE 1

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1994 ESTIMATES

PROJECT TITLE: Refurbish Launch Complex 39 Cooling System

INSTALLATION: John F. Kennedy Space Center

FY 1994 CoF Estimate: $4,000,000

LOCATION OF PROJECT: John F. Kennedy Space Center, Brevard County, Florida

COGNIZANT HEADQUARTERS OFFICE: Office of Space Flight

FY 1993 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF Funding	$378,000	---	$378,000
Capitalized Investment	---	$358,272,990	358,272,990
Total	$378,000	$358,272,990	$358,650,990

SUMMARY PURPOSE AND SCOPE:

This project provides for the refurbishment of four air handlers and the replacement of reheat coils throughout the Launch Control Center (LCC) and in the lowbay of the Vehicle Assembly Building (VAB). These modifications will be accomplished by installing new energy saving variable air volume (VAV) boxes and new VAV compatible heating, ventilating, and air conditioning equipment.

PROJECT JUSTIFICATION:

The associated air handling units and the reheat coils in both facilities are 25-30 years old and at the end of their original design life. The equipment is deteriorated, performance is diminished, and repair parts are difficult to obtain causing lengthy down times that delay shuttle processing and disrupt launch support operations. The constant volume configuration and poor condition of the air handling units coupled with the obsolete reheat coils result in an energy inefficient and unreliable system.

Conversion of this equipment to a variable air volume configuration would increase the reliability of the system and would be an energy efficient means of controlling the tight temperature and humidity requirements within the LCC and VAB.

IMPACT OF DELAY:

Failure to implement this project will result in continued inefficient operation of air handling units in the LCC and the lowbay of the VAB with possibility of system failures which could impact Shuttle launch activities.

PROJECT DESCRIPTION:

This project provides for the replacement of four air handlers and the replacement of reheat coils throughout the LCC and in the lowbay of the VAB. This project will include asbestos abatement and removal of reheat coils, cooling coils, supply and return fans, filter sections, miscellaneous piping, valves, ducts, dampers, insulation, and electrical power feeders. These items will be replaced with new energy efficient equipment including new controls, humidification systems, and variable air volume boxes.

PROJECT COST ESTIMATE:	Unit of Measure	Quantity	Unit Cost	Cost
Construction:	---	---	---	$4,000,000
Asbestos Abatement	LS	---	---	570,000
Mechanical	LS	---	---	2,250,000
Electrical	LS	---	---	1,180,000
Total				$4,000,000

LIST OF RELATED GRAPHICS: Figure 1 - Site Plan

OTHER EQUIPMENT SUMMARY: None.

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT: None.

JOHN F. KENNEDY SPACE CENTER
FISCAL YEAR 1994 ESTIMATES
REFURBISH LAUNCH COMPLEX 39 COOLING SYSTEM

SITE PLAN

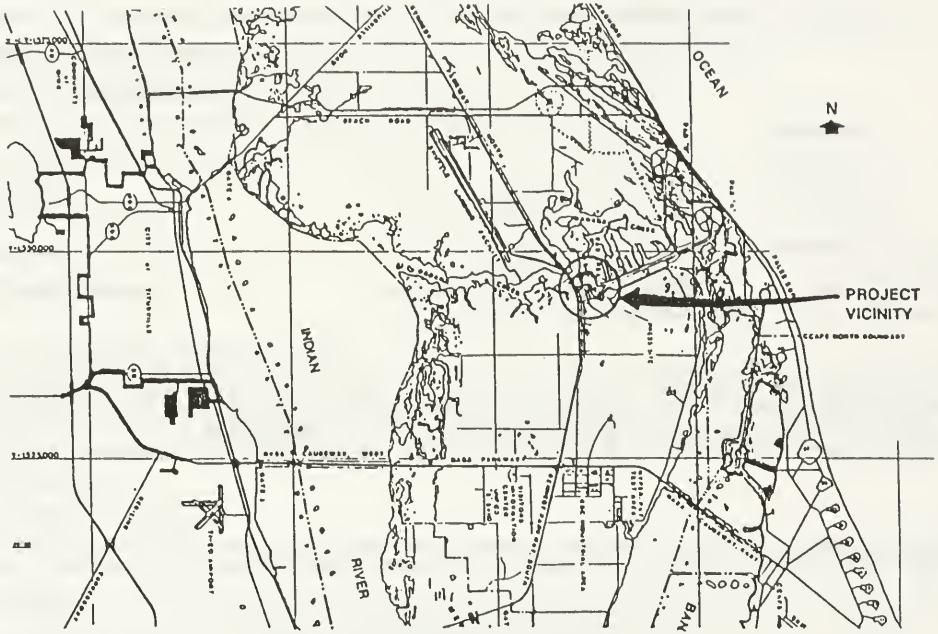


FIGURE 1

PROJECT TITLE: Refurbish Launch Complex 39 Secondary Circuit Breakers

INSTALLATION: John F. Kennedy Space Center

FY 1994 CoF Estimate: $3,300,000

LOCATION OF PROJECT: John F. Kennedy Space Center, Brevard County, Florida

COGNIZANT HEADQUARTERS OFFICE: Office of Space Flight

FY 1993 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF Funding	$266,000	---	$266,000
Capitalized Investment	---	$478,844,110	478,844,110
Total	$266,000	$478,844,110	$479,110,110

SUMMARY PURPOSE AND SCOPE:

This project provides for the refurbishment and service life extension of 480 Volt secondary circuit breakers and installation of state-of-the-art static trip overcurrent devices on the circuit breakers in the Launch Complex 39 (LC 39) area.

PROJECT JUSTIFICATION:

The existing circuit breaker overcurrent devices are 25 years old, difficult to maintain and spare parts are no longer made. The units do not have static overcurrent protection devices. The breaker settings cannot be verified because of the inaccuracy of the control devices. As a result, premature trips and unscheduled outages may occur. The new overcurrent protection will eliminate premature trips and/or failure to trip, thereby eliminating unscheduled outages and adverse impacts to shuttle processing.

IMPACT OF DELAY:

Premature tripping or failure to trip may occur, which would cause unscheduled outages or possible damage to critical equipment.

PROJECT DESCRIPTION:

This project will refurbish the existing 480 Volt sensitive secondary circuit breakers installed on LC-39 facilities and includes the installation of state-of-the-art static trip overcurrent devices on the circuit breakers.

PROJECT COST ESTIMATE:	Unit of Measure	Quantity	Unit Cost	Cost
Construction:	---	---	---	$3,300,000
LCC Breakers	LS	---	---	570,000
Mobile Launch Platforms 1,2,3 & Vehicle Assembly Building Repeater (VABR) Breakers . . .	LS	---	---	1,130,000
Vehicle Assembly Building Breakers	LS	---	---	710,000
Pads A & B Breakers	LS	---	---	890,000
Total				$3,300,000

LIST OF RELATED GRAPHICS: Figure 1 - Location Plan

OTHER EQUIPMENT SUMMARY: None

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT: None

JOHN F. KENNEDY SPACE CENTER
FISCAL YEAR 1994 ESTIMATES
REFURBISH LAUNCH COMPLEX 39 SECONDARY CIRCUIT BREAKERS

LOCATION PLAN

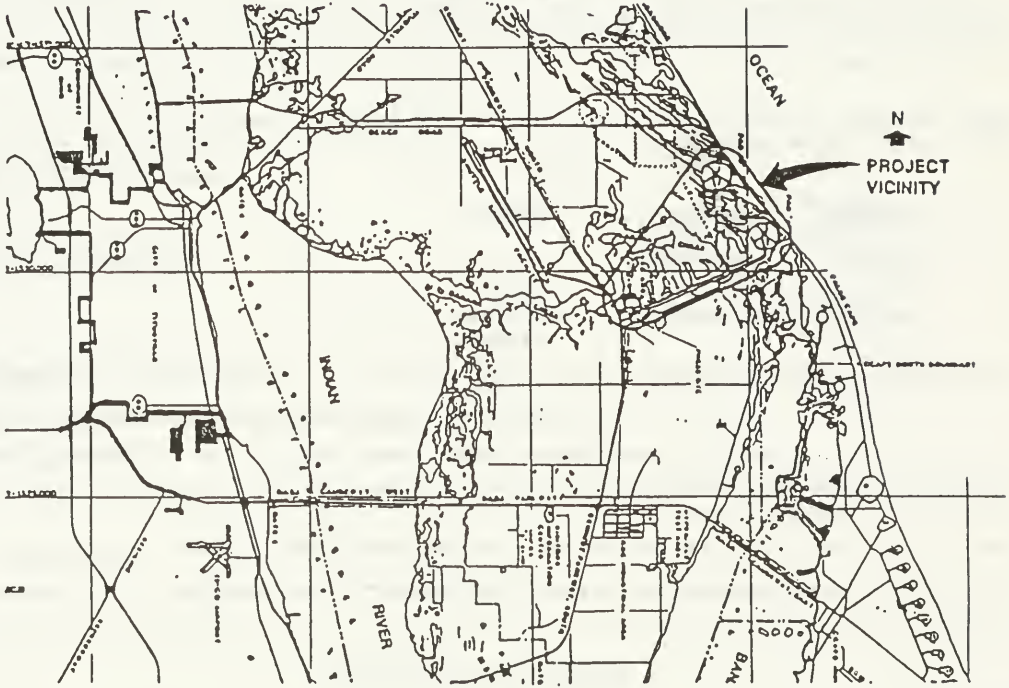


FIGURE 1

CF 1-18

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1994 ESTIMATES

PROJECT TITLE: Refurbish Vehicle Assembly Building/Pad Water Storage Tanks

INSTALLATION: John F. Kennedy Space Center

FY 1994 CoF Estimate: $3,000,000

LOCATION OF PROJECT: John F. Kennedy Space Center, Brevard County, Florida

COGNIZANT HEADQUARTERS OFFICE: Office of Space Flight

FY 1993 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF Funding	$253,000	---	$ 253,000
Capitalized Investment	---	$5,879,292	5,879,292
Total	$253,000	$5,879,292	$6,132,292

SUMMARY PURPOSE AND SCOPE:

This project provides for refurbishment of the two 1,000,000 gallon ground storage water tanks and constructing two additional 1,000,000 gallon tanks near the Vehicle Assembly Building (VAB) and launch pads 39A and B.

PROJECT JUSTIFICATION:

Two new water tanks are required to provide redundancy and preclude a two-month shutdown to refurbish the existing 27-year-old tanks. Safety and launch operations personnel require the existing Shuttle fire protection systems to remain operational at all times. Therefore, new tanks will be constructed and become operational before the existing tanks are allowed to be taken out of service and refurbished. Existing tank refurbishment is required to repair existing corrosion damage.

IMPACT OF DELAY:

Failure to approve this project will delay repair of both tanks and could cause delay in Shuttle processing schedules due to inevitable corrosive failure of the tank walls.

PROJECT DESCRIPTION:

This project provides for two new 1,000,000 gallon tanks to be installed near the VAB and launch pads and tied into the existing water system. The two existing 1,000,000 gallon tanks will then be taken out of service for sand blasting, painting, and miscellaneous repairs. New cathodic protection systems will be provided for the four tanks.

PROJECT COST ESTIMATE:	Unit of Measure	Quantity	Unit Cost	Cost
Construction:	---	---	---	$3,000,000
Tank Refurbishment	EA	2	403,000	806,000
New Tank Installation	EA	2	1,097,000	2,194,000
Total				$3,000,000

LIST OF RELATED GRAPHICS: Figure 1 - Site Plan

OTHER EQUIPMENT SUMMARY: None

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT: None

68-668 O—93——18

JOHN F. KENNEDY SPACE CENTER
FISCAL YEAR 1994 ESTIMATES
REFURBISH VEHICLE ASSEMBLY BUILDING/PAD WATER STORAGE TANKS

SITE PLAN

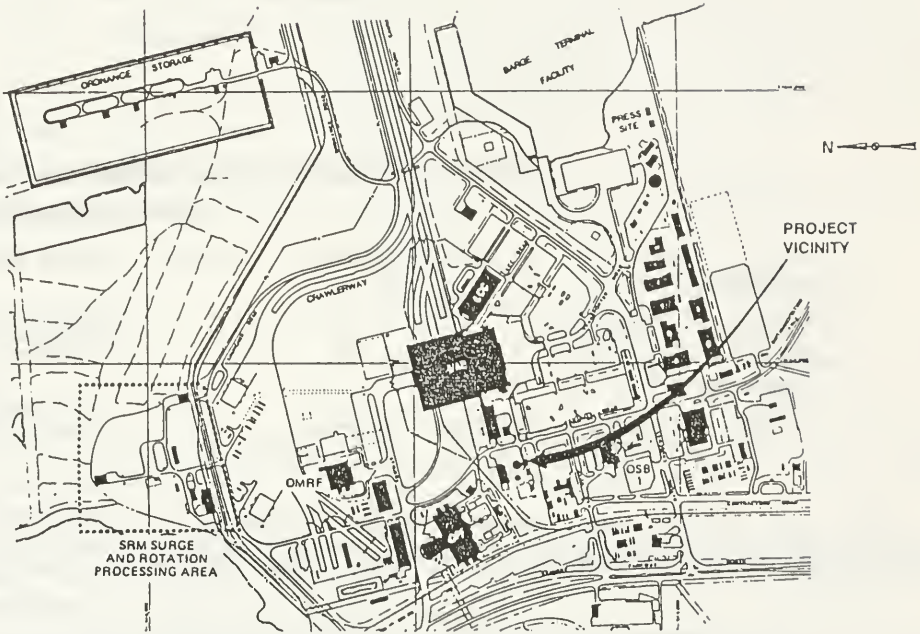


FIGURE 1

PROJECT TITLE: Rehabilitate Industrial Area Fire Alarm Reporting System

INSTALLATION: John F. Kennedy Space Center

FY 1994 CoF Estimate: $4,900,000

LOCATION OF PROJECT: John F. Kennedy Space Center, Brevard County, Florida

COGNIZANT HEADQUARTERS OFFICE: Office of Space Flight

FY 1993 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF Funding	$476,000	---	$ 476,000
Capitalized Investment	---	$2,402,000	2,402,000
Total	$476,000	$2,402,000	$2,878,000

SUMMARY PURPOSE AND SCOPE:

This project will replace existing unreliable and outdated fire alarm control and monitoring systems in the Industrial Area with microprocessor-based panels to be monitored and controlled through the existing central supervising station, located in the Launch Control Center.

PROJECT JUSTIFICATION:

The existing nonrecording, annunciator type fire alarm reporting and monitoring systems are unreliable, new facilities or zones cannot be added, and do not meet the updated recommendations of the National Fire Code. The existing monitoring systems are highly dependent on operator vigilance, proficiency, interpretation, and recording, and are incapable of monitoring individual fire alarm zones in large buildings. Repair parts are very difficult and costly to obtain for these obsolete systems. The increased frequency of hazardous operations within the industrial area makes the need for better control and monitoring of fire alarm and suppression systems essential.

IMPACT OF DELAY:

Deferral of this project will result in a continued inefficiency in the evaluation of fire signals received by the central fire alarm monitoring system. Without this project, there would be an increase in the risk of misdirecting the fire department, which adds delays to the critical response time.

PROJECT DESCRIPTION:

This project will replace existing critical safety system fire alarm control and monitoring systems with microprocessor-based panels. Each facility's heat/smoke detection/signaling zones will be modified to be compatible with the new fire alarm panel, which will be compatible with the central station equipment, graphics, archiving and control functions. After the fire alarm systems are integrated with the central station, including graphics and base central processing unit, the system will provide reporting and control of individual alarm points.

PROJECT COST ESTIMATE:	Unit of Measure	Quantity	Unit Cost	Cost
Construction:	---	---	---	$4,900,000
Demolition	LS	---	---	70,000
Fire Alarm Panels	EA	41	13,902.44	570,000
Modem Packages	EA	27	6,888.89	186,000
Detectors	EA	1,450	105.52	153,000
Bell Units	EA	1,430	130.07	186,000
Wire and Conduit.	LF	125,600	22.85	2,870,000
Asbestos Abatement	LS	---	---	620,000
Head End Equipment	LS	---	---	245,000
Total				$4,900,000

LIST OF RELATED GRAPHICS: Figure 1 - Location Plan

OTHER EQUIPMENT SUMMARY: None

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT: None

JOHN F. KENNEDY SPACE CENTER
FISCAL YEAR 1994 ESTIMATES
REHABILITATE INDUSTRIAL AREA FIRE ALARM REPORTING SYSTEM

LOCATION PLAN

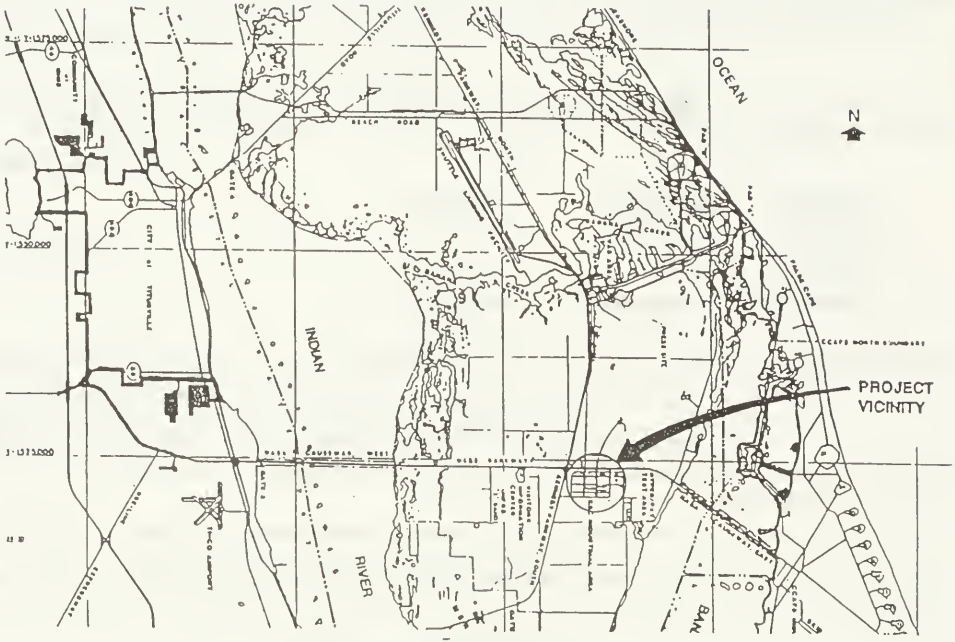


FIGURE 1

PROJECT TITLE: Restore C-5 Substation, Launch Complex 39 Area

INSTALLATION: John F. Kennedy Space Center

FY 1994 CoF Estimate: $5,000,000

LOCATION OF PROJECT: John F. Kennedy Space Center, Brevard County, Florida

COGNIZANT HEADQUARTERS OFFICE: Office of Space Flight

FY 1993 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF Funding	$300,000	---	$ 300,000
Capitalized Investment	---	$4,705,523	4,705,523
Total	$300,000	$4,705,523	$5,005,523

SUMMARY PURPOSE AND SCOPE:

This project provides for the expansion of the C-5 electrical distribution substation to provide necessary load relief to the existing C-5 substation and to support planned load increases in the Launch Complex 39 (LC-39) area.

PROJECT JUSTIFICATION:

This restoration project is required to correct the overload condition of the existing C-5 substation design capacity of 30 megaVolt Amperes (mva). Actual peak demand in FY 1990 and 1991 was 29.8 mva and load growth in the LC-39 area exceeded the design capacity in FY 1992. The peak substation capacity utilizing cooling fans will be exceeded by the end of FY 1994. Exceeding the substation design capacity is not recommended for extended periods of time as this reduces transformer service life. Once this upgrade becomes operational, it will provide the needed capacity to alleviate the overloaded condition and provide for planned growth in the LC-39 area.

IMPACT OF DELAY:

Failure to provide the expansion will result in the C-5 substation peak capacity being exceeded and eventual transformer failures. It will also force undesirable load shedding during critical launch operations beginning in FY 1994.

PROJECT DESCRIPTION:

This project provides for increasing the capacity a minimum of 20 mva, which includes 13,800 volt feeders, feeder breakers, manholes, duct banks, feeder bays, control building, protective devices, public utility interface and a fenced enclosure. The protective devices, substation structure, feeder bays, and yard will be designed to allow for growth of the substation to reduce the cost impact of modifications and retrofitting at the time of future expansion.

PROJECT COST ESTIMATE:	Unit of Measure	Quantity	Unit Cost	Cost
Construction:	---	---	---	$5,000,000
Civil/Site	LS	---	---	180,000
General	LS	---	---	60,000
Mechanical	LS	---	---	275,000
Electrical	LS	---	---	4,485,000
Total				$5,000,000

LIST OF RELATED GRAPHICS: Figure 1 - Location Plan

OTHER EQUIPMENT SUMMARY: Approximately $150,000 of Non-CoF equipment will be provided.

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT: None

JOHN F. KENNEDY SPACE CENTER
FISCAL YEAR 1994 ESTIMATES
RESTORE C-5 SUBSTATION, LAUNCH COMPLEX 39 AREA

LOCATION PLAN

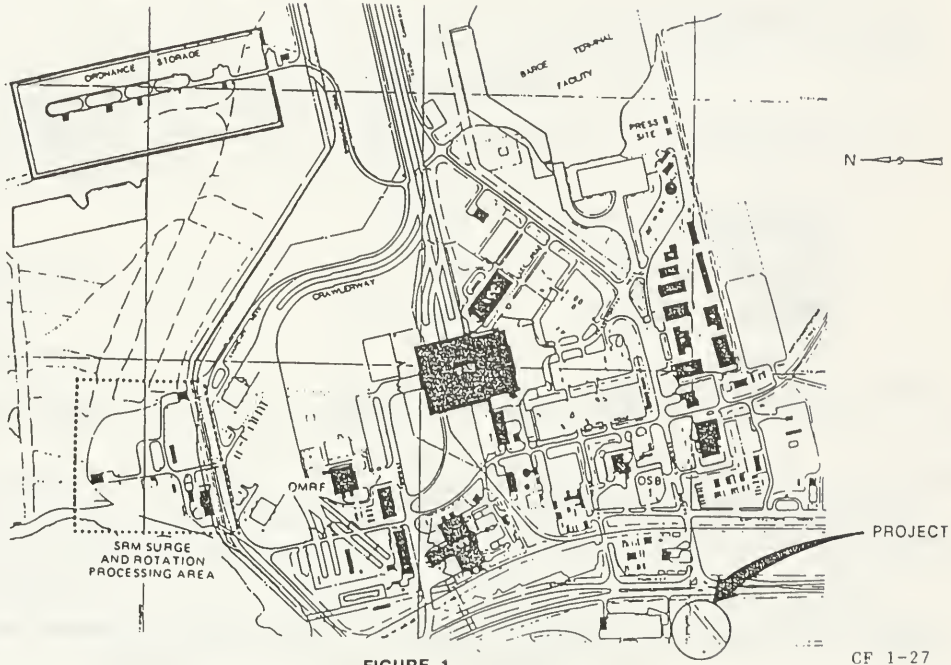


FIGURE 1

CF 1-27

PROJECT TITLE: Restoration of High Pressure Air Compressor System

INSTALLATION: George C. Marshall Space Flight Center

FY 1994 CoF Estimate: $8,500,000

LOCATION OF PROJECT: Marshall Space Flight Center, Madison County, Alabama

COGNIZANT HEADQUARTERS OFFICE: Office of Space Flight

FY 1993 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF Funding	$664,000	---	$ 664,000
Capitalized Investment	---	$3,447,111	3,447,111
Total	$664,000	$3,447,111	$4,111,111

SUMMARY PURPOSE AND SCOPE:

The purpose of this project is to replace the existing High Pressure Air Compressor System, which services the Center's laboratories and test areas. This project provides for the construction of a new air compressor facility with three compressors and space for three more. High pressure air is essential to operate all of the Center's major testing facilities.

PROJECT JUSTIFICATION:

This system provides high pressure air for purging operations, test area operations, wind tunnel operations, contamination control, critical pneumatic systems, scientific experiments, and neutral buoyancy activities. The existing compressors are 26 to 40 years old and very deteriorated. During the past two years, compressor downtime has resulted in a 23 percent reduction in rated compressor output. Compressor downtime can commonly run into months because of the unavailability of parts. With the High Pressure Air Compressor System already operating

at capacity, the loss of one compressor results in program testing delays. The existing facilities are not suitable for refurbishment and will be deactivated and demolished after this facility is fully operational.

IMPACT OF DELAY:

Delay of this project will impact all ongoing programs at the Center. Support of test programs will become increasingly unreliable and costly due to continued equipment failure and difficulty of maintenance.

PROJECT DESCRIPTION:

This project provides an approximately 13,000 square foot air compressor building, including foundations, trenches, and utility systems. Also included is the installation of three electric motor driven air compressors with associated switchgear, and a new 10 MVA electrical unit substation. Space will be provided for three additional compressor units. An air purification system will be installed. The facility will have a fully equipped sound-proof control room and a bridge crane. Approximately 7,700 linear feet of pipe will be used to connect into and refurbish the existing air distribution system.

PROJECT COST ESTIMATE:	Unit of Measure	Quantity	Unit Cost	Cost
Construction	---	---	---	$8,500,000
Site Work	LS	---	---	600,000
Architectural/Structural . .	LS	---	---	2,700,000
Mechanical	LS	---	---	3,200,000
Electrical	LS	---	---	2,000,000
Total				$8,500,000

LIST OF RELATED GRAPHICS: Figure 1 - Location Plan

OTHER EQUIPMENT SUMMARY: None

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT: Future funding required to complete the replacement of the entire High Pressure Air Compressor System is estimated to cost approximately $6,000,000 FY 1995-FY 1996.

MARSHALL SPACE FLIGHT CENTER
FISCAL YEAR 1994 ESTIMATES
RESTORATION OF HIGH PRESSURE AIR COMPRESSOR SYSTEM

LOCATION PLAN

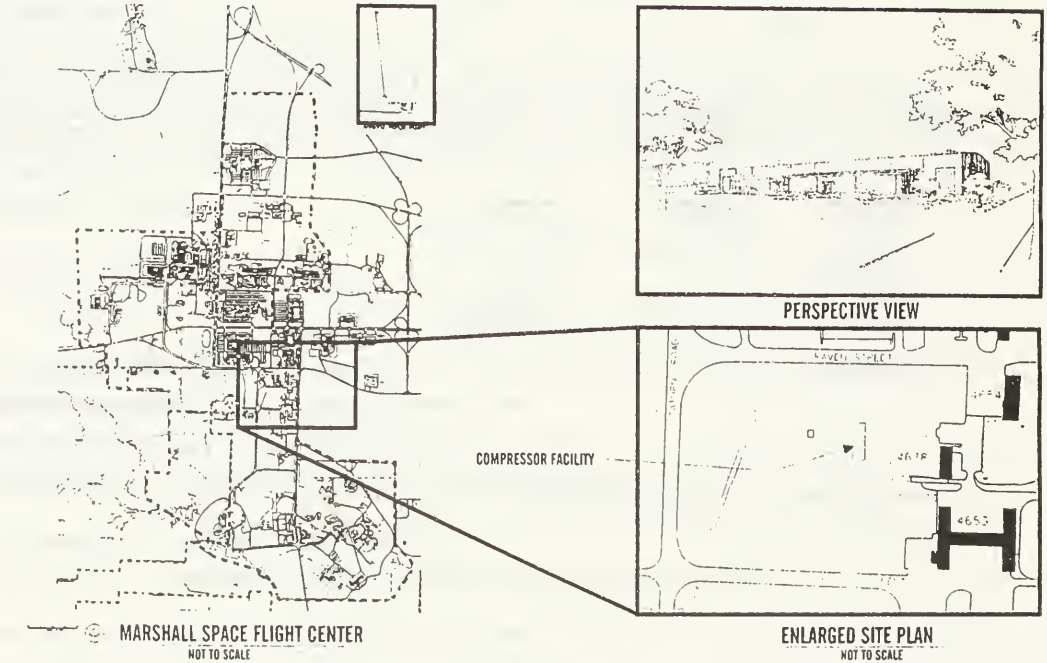


FIGURE 1

CF 1-30

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1994 ESTIMATES

PROJECT TITLE: Repair Decking and Roof, X-Ray and Staging Facility

INSTALLATION: Michoud Assembly Facility

FY 1994 CoF Estimate: $1,500,000

LOCATION OF PROJECT: New Orleans, Orleans Parish, Louisiana

COGNIZANT HEADQUARTERS OFFICE: Office of Space Flight

FY 1993 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF Funding	$105,000	---	$ 105,000
Capitalized Investment	---	$9,611,664	9,611,664
Total	$105,000	$9,611,664	$9,716,664

SUMMARY PURPOSE AND SCOPE:

The purpose of this project is to repair the decking and roof system of the X-Ray and Staging Facility to ensure its structural integrity and to protect completed External Tanks stored in the facility for future Space Shuttle missions. Work to be performed includes removal of the existing roofing system and concrete decking, installation of corrugated metal decking, and the installation of a new roofing system.

PROJECT JUSTIFICATION:

The X-Ray and Staging Facility is used to modify and store completed External Tanks. Inspection of the decking revealed cracking and spalling of several concrete ceiling panels. This condition developed because the building had no ventilation, and moisture accumulated within the facility. In addition, the roof leaked, exposing the steel reinforcement bars to moisture. The resulting

oxidation of the rebar caused expansion, which in turn caused the concrete around the panel flange area to crack and spall. Temporary repairs will no longer rectify the problem. A recent study by an independent roofing consultant recommended complete replacement of the concrete decking with a metal decking, and installation of a new built-up roof.

IMPACT OF DELAY:

Delay of this project will allow continued spalling of the concrete, increasing the risk of damage to the stored External Tanks and support equipment from falling concrete.

PROJECT DESCRIPTION:

This project provides for the removal of the existing four-ply roofing system and approximately 6,000 panels of concrete decking. The decking will be replaced with approximately 2,600 square feet of corrugated metal. A new built-up roofing system including insulation and flashing will be installed. Roof drains will be modified and/or replaced as required.

PROJECT COST ESTIMATE:	Unit of Measure	Quantity	Unit Cost	Cost
Construction	---	---	---	$1,500,000
Replacement of Decking and Roof	LS	---	---	1,500,000
Total				$1,500,000

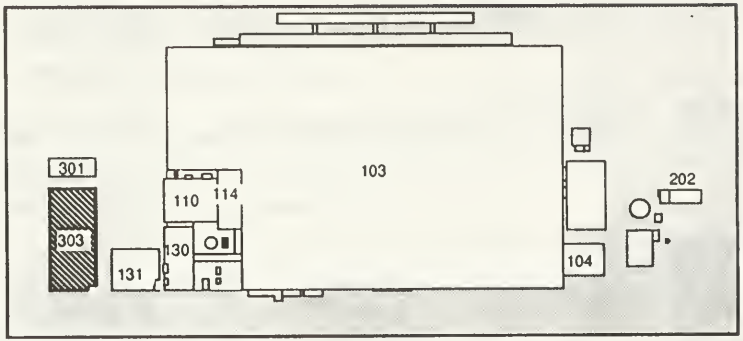
LIST OF RELATED GRAPHICS: Figure 1 - Site Plan

OTHER EQUIPMENT SUMMARY: None

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT: None

MICHOUD ASSEMBLY FACILITY
FISCAL YEAR 1994 ESTIMATES
REPAIR DECKING AND ROOF, X-RAY AND STAGING FACILITY

SITE PLAN



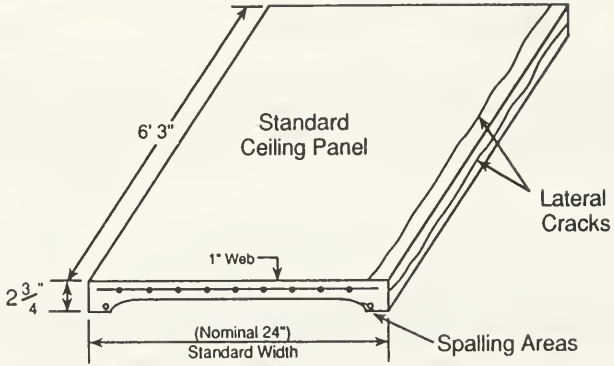


FIGURE 1

PROJECT TITLE: Replace Cooling Tower and Boiler

INSTALLATION: Michoud Assembly Facility

FY 1994 CoF Estimate: $4,000,000

LOCATION OF PROJECT: New Orleans, Orleans Parish, Louisiana

COGNIZANT HEADQUARTERS OFFICE: Office of Space Flight

FY 1993 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF Funding	$424,000	$2,300,000	$2,724,000
Capitalized Investment	---	5,201,098	5,201,098
Total	$424,000	$7,501,098	$7,925,098

SUMMARY PURPOSE AND SCOPE:

The purpose of this project is to continue the systematic replacement of major central heating and cooling plant components in the 202/207 complex. This phase provides for the replacement of a six-cell cooling tower and a 60,000 lb/hr steam boiler, which support production, engineering, storage, and administrative areas.

PROJECT JUSTIFICATION:

Cooling Tower 202 was constructed in 1953. A majority of the wooden members are rotting. The fan system is corroded, and fans, pumps, and other mechanical equipment have vibration problems as a result of deteriorated structural components. There are visible cracks around the entire perimeter of the foundation resulting in the leakage of treated cooling water. The upper deck, used by personnel to accomplish maintenance and repairs, is structurally unsafe. Steam Boiler No. 1 was also installed in 1953. It has extensive corrosion throughout, and replacement parts

are no longer available. Both the cooling tower and the steam boiler are reaching the point where corrective maintenance is no longer effective; complete replacement is needed.

IMPACT OF DELAY:

Continued deterioration of heating and cooling components will result in External Tank production disruptions and potential production rework. Critical production activities such as Spray-on Foam Insulation (SOFI) spray and curing, component cleaning, liquid hydrogen and oxygen tank cleaning, Liquid Oxygen Tank priming, and tank welding will be adversely impacted.

PROJECT DESCRIPTION:

This project provides for the installation of a new ceramic six-cell cooling tower, with associated pumps, motors, piping, and valves, on a new pile-supported foundation. The sump and piping common to Cooling Towers 202 and 208 will also be replaced. The existing cooling tower and foundation will be demolished after the new cooling tower is activated. The project also provides for the demolition of an existing 60,000 lb/hr steam boiler, and its replacement with a high-efficiency boiler of equal capacity. An access door will be required to place the new boiler in the proper location; therefore, one section of the west wall will be removed and replaced with a roll-up door.

PROJECT COST ESTIMATE:	Unit of Measure	Quantity	Unit Cost	Cost
Construction	---	---	---	$4,000,000
Structural	LS	---	---	800,000
Mechanical	LS	---	---	1,500,000
Electrical	LS	---	---	350,000
Asbestos Abatement	LS	---	---	200,000
Cooling Tower Set in Place	LS	---	---	1,150,000
Total				$4,000,000

LIST OF RELATED GRAPHICS: Figure 1 - Cooling Tower Site Plan
Figure 2 - Boiler House Site Plan1

OTHER EQUIPMENT SUMMARY: None

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

Future funding to complete the replacement of all major heating and cooling equipment in the 202/207 complex is approximately $5,000,000 in FY 1996.

MICHOUD ASSEMBLY FACILITY
FISCAL YEAR 1994 ESTIMATES
REPLACE COOLING TOWER AND BOILER
COOLING TOWER 202 SITE PLAN

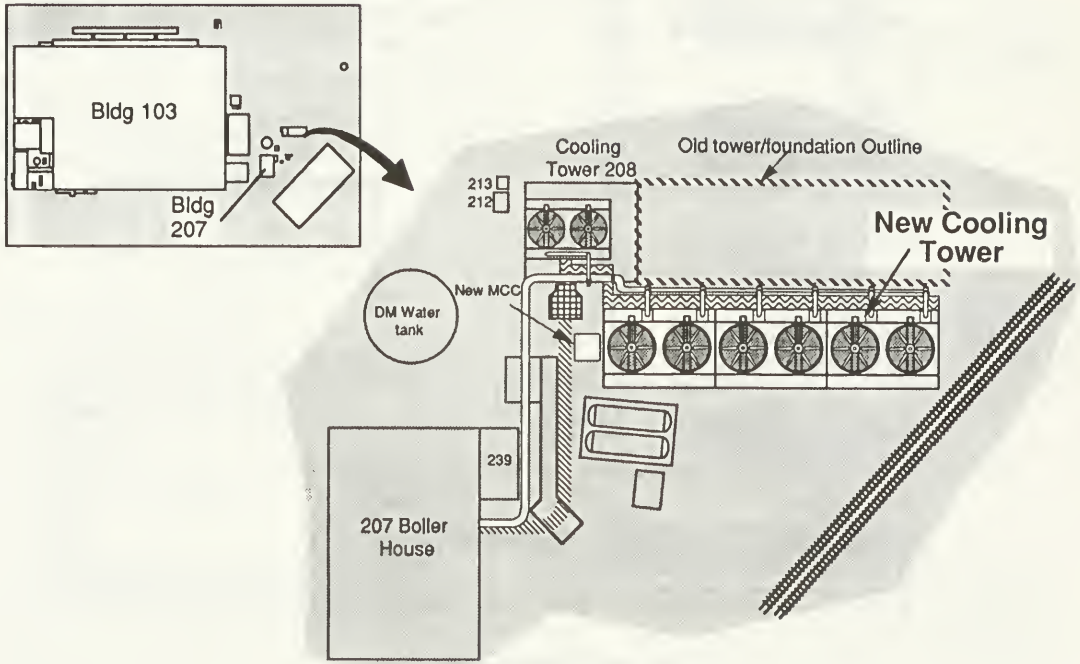
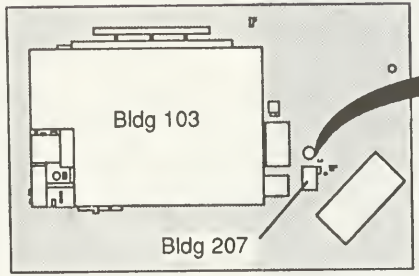
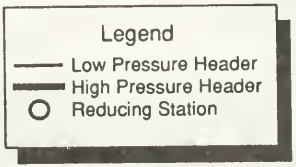


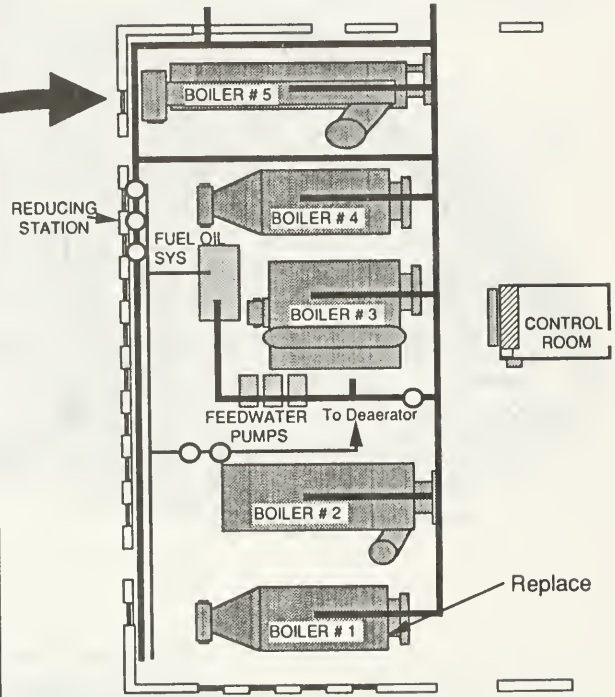
FIGURE 1

MICHOUD ASSEMBLY FACILITY
FISCAL YEAR 1994 ESTIMATES
REPLACE COOLING TOWER AND BOILER
BOILER HOUSE 207 SITE PLAN





Boiler	Year Installed	Gross Capacity (lbs/hr)	Status
1	1952	60,000	Replace, FY94
2	1982	75,000	Active
3	1964	75,000	Replace, FY93
4	1952	60,000	Replace, FY93
5	1965	100,000	Active



Partial Floor Plan
Building 207

FIGURE 2

PROJECT TITLE: Restore SSME Test Complex High Pressure Industrial Water System

INSTALLATION: John C. Stennis Space Center

FY 1994 CoF Estimate: $2,300,000

LOCATION OF PROJECT: Stennis Space Center, Hancock County, Mississippi

COGNIZANT HEADQUARTERS OFFICE: Office of Space Flight

FY 1993 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF Funding	$30,000	---	$ 30,000
Capitalized Investment	---	$3,908,915	3,908,915
Total	$30,000	$3,908,915	$3,938,915

SUMMARY PURPOSE AND SCOPE:

This project provides for the restoration of the High Pressure Industrial Water (HPIW) system at the Space Shuttle Main Engine (SSME) "A-1" and "A-2" Test Stands.

PROJECT JUSTIFICATION:

The High Pressure Industrial Water piping systems are more than 25 years old and many of the lines are beginning to experience failures due to severe corrosion and erosion. Recent failures have required fabrication of large replacement sections instead of patching due to the loss of wall thickness from erosion and cavitation. Loss of any single major section of piping serving the deflector, diffuser, or deluge systems will result in loss of fire protection, a critical safety system on the test stands and at the barge docks. In addition, replacement of a large pipe would require long lead time procurement, causing a major SSME testing program interruption. Maintenance requirements are increasing as system reliability and availability are degrading on

this critical safety system. Repair is required to prevent system failure during critical operations and to control escalating maintenance costs.

IMPACT OF DELAY:

A delay in the implementation of this project will jeopardize system reliability and availability and could result in a major SSME Testing Program interruption.

PROJECT DESCRIPTION:

This project provides for the restoration of the High Pressure Industrial Water system at the SSME "A-1" and "A-2" Test Stands. Work includes replacement of the large diameter corroded/eroded HPIW piping system, re-routing of the water line that supports the "A-2" Test Stand LH2 barge dock deluge system, replacement of two 24-inch riser valves, and replacement of the "Flex-Flo" deluge system control valves.

PROJECT COST ESTIMATE:	Unit of Measure	Quantity	Unit Cost	Cost
Construction	---	---	---	$2,300,000
Excavation & Backfill . . .	LS	---	---	173,000
HPIW Pipe	LF	3,000	520.67	1,562,000
Deluge Pipe	LF	750	236.00	177,000
24" Riser Valves	EA	2	68,500.00	137,000
"Flex-Flo" Valves	EA	22	11,409.10	251,000
Total				$2,300,000

LIST OF RELATED GRAPHICS: Figure 1 - Location Plan

OTHER EQUIPMENT SUMMARY: None

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT: None

JOHN C. STENNIS SPACE CENTER
FISCAL YEAR 1994 ESTIMATES
RESTORE SSME TEST COMPLEX HIGH PRESSURE INDUSTRIAL WATER SYSTEM

LOCATION PLAN

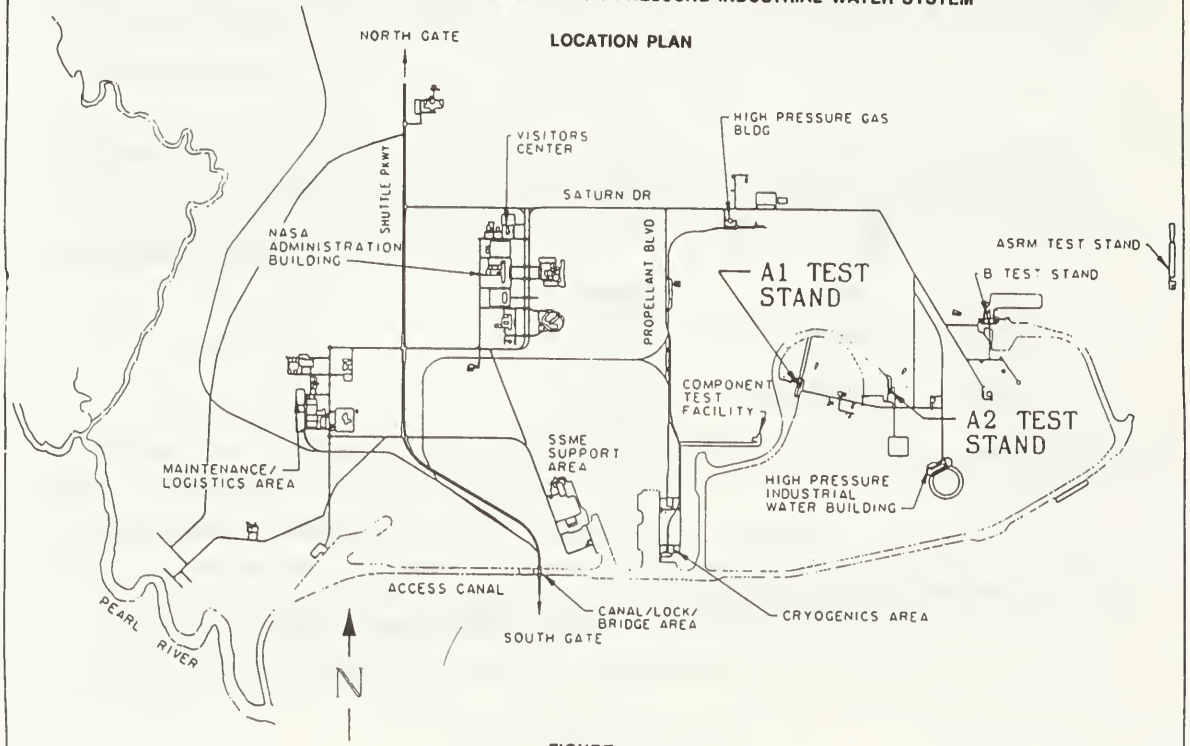


FIGURE 1

PROJECT TITLE: Restore High Pressure Gas Storage Capacity

INSTALLATION: John C. Stennis Space Center

FY 1994 CoF Estimate: $2,300,000

LOCATION OF PROJECT: Stennis Space Center, Hancock County, Mississippi

COGNIZANT HEADQUARTERS OFFICE: Office of Space Flight

FY 1993 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF Funding	$135,000	---	$135,000
Capitalized Investment	---	$100,000	100,000
Total	$135,000	$100,000	$235,000

SUMMARY PURPOSE AND SCOPE:

The purpose of this project is to restore high-pressure gas storage capacity in the Space Shuttle Main Engine (SSME) Test Complex at Stennis Space Center (SSC) to ensure the safety and reliability of the high-pressure system. Work includes the installation of approximately 1,250 cubic feet of storage capacity with supporting structure and the fabrication and cleaning of all associated piping and components necessary for connection to the existing gaseous hydrogen system.

PROJECT JUSTIFICATION:

The high-pressure gas storage vessels provide direct support to the Space Shuttle Main Engine (SSME) Test Complex during propulsion testing activity. Many of these vessels were fabricated in the early 1960s from HS-1A (T-1) steel. A 1,250 cubic foot gaseous hydrogen (GH_2) storage vessel has been removed from service because of defects in the vessel wall detected during the Pressure Vessel Recertification Program. Internal inspection of GH_2 storage vessels are required to be performed in five-year intervals. This cannot be accomplished in the SSME "A" Test Complex,

however, because it requires the vessels to be put out of service for a period of four to six weeks each. There currently is not enough reserve capacity available to support SSME testing activities during these periods because a vessel had to be removed from service.

IMPACT OF DELAY:

A delay in the implementation of this project will result in the continued operation of the critical high-pressure gas system at the marginal limits of the GH_2 storage capacity and will require a pressure vessel recertification waiver.

PROJECT DESCRIPTION:

This project includes the procurement and installation of two high-pressure GH_2 vessels (approximately 1,250 cubic feet of storage capacity) with supporting structure, and the fabrication and cleaning of all associated piping and components necessary for connection to the existing gaseous hydrogen system.

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Cost
Construction	---	---	---	$2,300,000
Vessels	EA	2	$934,500	1,869,000
Installation	EA	2	43,000	86,000
Foundations	EA	2	57,000	114,000
Piping	LS	---	---	231,000
Total				$2,300,000

LIST OF RELATED GRAPHICS: Figure 1 - Location Plan

OTHER EQUIPMENT SUMMARY: None

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT: None

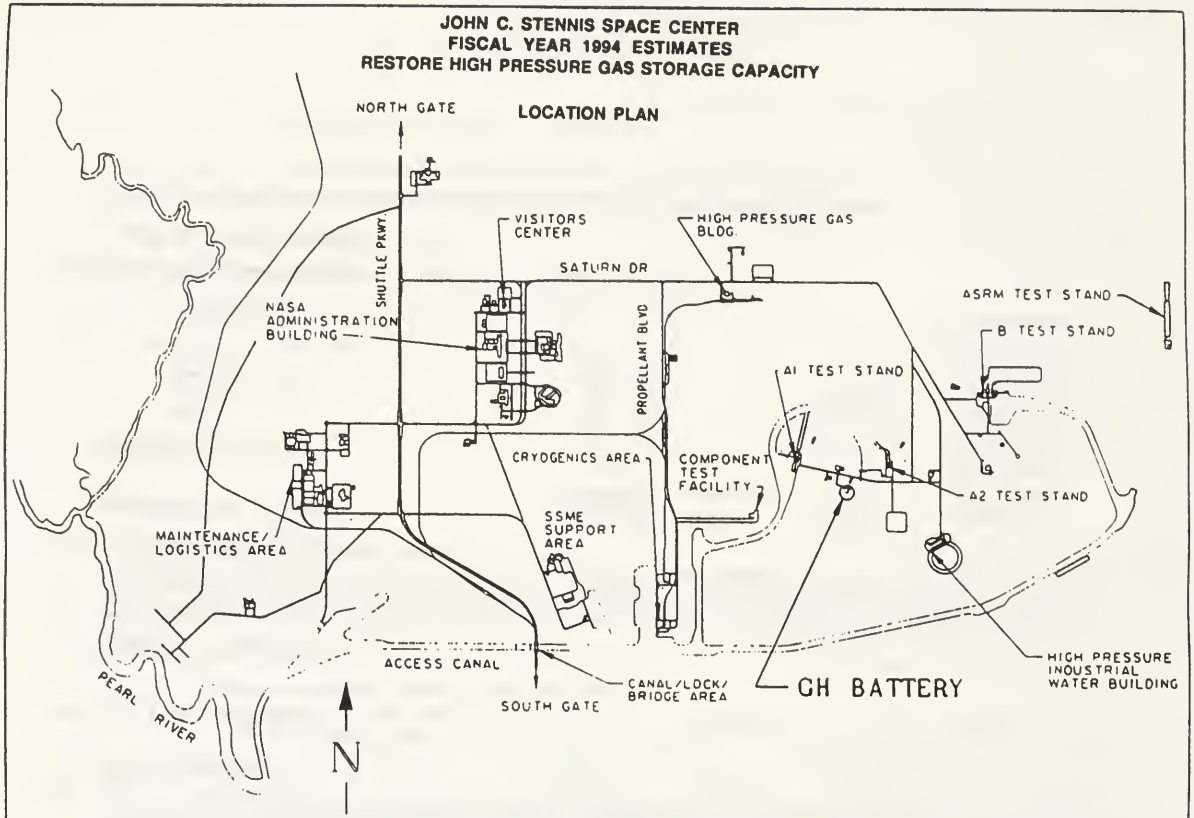

JOHN C. STENNIS SPACE CENTER
FISCAL YEAR 1994 ESTIMATES
RESTORE HIGH PRESSURE GAS STORAGE CAPACITY
LOCATION PLAN
NORTH GATE
SHUTTLE PKWY.
VISITORS CENTER
HIGH PRESSURE GAS BLDG.
SATURN DR
NASA ADMINISTRATION BUILDING
PROPELLANT BLVD
ASRM TEST STAND
B TEST STAND
A1 TEST STAND
CRYOGENICS AREA
COMPONENT TEST FACILITY
A2 TEST STAND
SSME SUPPORT AREA
MAINTENANCE/ LOGISTICS AREA
ACCESS CANAL
CANAL/LOCK/ BRIDGE AREA
SOUTH GATE
GH BATTERY
HIGH PRESSURE INDUSTRIAL WATER BUILDING
PEARL RIVER
N

FIGURE 1

PROJECT TITLE: Construction of Advanced Solid Rocket Motor Program Facilities

INSTALLATION: Various Locations

FY 1994 CoF Estimate: $32,600,000

LOCATION OF PROJECT: Various Locations

COGNIZANT HEADQUARTERS OFFICE: Office of Space Flight

FY 1993 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning, Design and Construction Management	Construction	Equipment Procurement	Total
Specific CoF Funding	$64,700,000	$285,770,000	$163,000,000	$513,470,000
Capitalized Investment	---	---	---	---
Total	$64,700,000	$285,770,000	$163,000,000	$513,470,000

SUMMARY PURPOSE AND SCOPE:

This continues the construction of Advanced Solid Rocket Motor (ASRM) facility projects, technical support, design, and construction management. ASRM is needed to improve margins of safety and reliability, increase payload lift, and add mission capability to the Space Transportation System. The Yellow Creek site in Northeastern Mississippi is the primary site for the production facilities; Stennis Space Center is the primary site for testing facilities; Michoud Assembly Facility is the site for nozzle manufacturing facilities; and rocket motor handling and assembly facilities modifications are included at the Kennedy Space Center. Additional component manufacturing or test facilities of a minor nature may be located at other sites as required.

PROJECT JUSTIFICATION:

The ASRM will improve the safety and reliability margins of the Solid Rocket Motor (SRM) and Space Shuttle vehicle by reducing or eliminating more than 200 critical failure modes. It also will provide the Shuttle with a significant gain in performance by providing an additional 12,000 pounds of payload capability. Moreover, development of the ASRM will strengthen the technical foundation upon which the United States' leadership in solid fueled rockets can be maintained. Production of the ASRM will require modern and automated facilities with greatly improved manufacturing and quality control processes. The facilities will be designed at a size to support manufacturing of sufficient ASRM flight sets to meet currently planned Space Shuttle launch rates. The present manufacturing process is labor-intensive with many opportunities for human error and requires excessive inspection efforts to ensure achievement of required standards. The new facilities will incorporate state-of-the-art computer controlled manufacturing and assembly techniques to enhance the reliability and safety margins of the rocket motor, reduce human error, and provide more effective inspection techniques.

IMPACT OF DELAY:

Delay of this project will delay improvements in Space Shuttle reliability, safety margins and payload lift.

PROJECT DESCRIPTION:

The total facility construction program is phased over several fiscal years and includes the following major elements of work: site preparation, utilities, manufacturing and production buildings, test facilities, motor handling and assembly facilities, other required support facilities, and special facilities-related equipment.

The FY 1994 phase of the overall ASRM facility construction program encompasses the following continuation of work: site preparation including fencing, railroad, and parking lots; expansion and extension of existing utilities including raw water, potable water, storm and sanitary sewer, waste treatment, electrical substations and power distribution and communications systems; static test complex including test stand, control building, hydrotest stand, meteorological facility and barge dock; motor propellent mix/cast/cure complex; motor case refurbishment and preparation facility; motor finish facility; non-destructive test (NDT) facility; nozzle manufacturing complex; production support office; quality assurance test laboratory; security/medical facility; fire station; warehouse buildings and transient/pressure test facility; rotation/processing/storage facility and barge dock modifications.

FY 1994 PROJECT COST ESTIMATE:

The project cost estimate is based on relatively mature criteria and design documentation. As manufacturing concepts are finalized and facility requirements are validated, it is possible that priorities may change and revisions and/or additions to the facilities and estimated costs may be necessary.

	FY 89-93	FY 94
Land Acquisition	$ 5,700,000	---
Technical Support, Studies, Design & Construction Management	$64,700,000	---
Construction	$280,070,000	$32,600,000
Site/Utilities	(62,000,000)	(2,000,000)
Motor Propellent Mix/Cast	(55,000,000)	(5,000,000)
Motor Case Prep/Refurb	(40,000,000)	---
Motor Finish/NDE	(24,000,000)	---
Nozzle Manufacture Complex (MAF)	(25,000,000)	(6,600,000)
Static Test Complex (SSC)	(33,600,000)	---
Component Test Complex (MSFC)	(1,170,000)	---
Handling & Assembly Facilities (KSC)	(21,300,000)	(18,500,000)
Support Facilities	(18,000,000)	(500,000)
Subtotal	$280,070,000	$32,600,000
Special Facilities Related Equipment	163,000,000	---
Total	$513,470,000	$32,600,000

LIST OF RELATED GRAPHICS: Figure 1: ASRM-Yellow Creek Site.
Figure 2: ASRM-Michoud Nozzle Manufacture Site.
Figure 3: ASRM-Stennis Test Site.

OTHER EQUIPMENT SUMMARY:

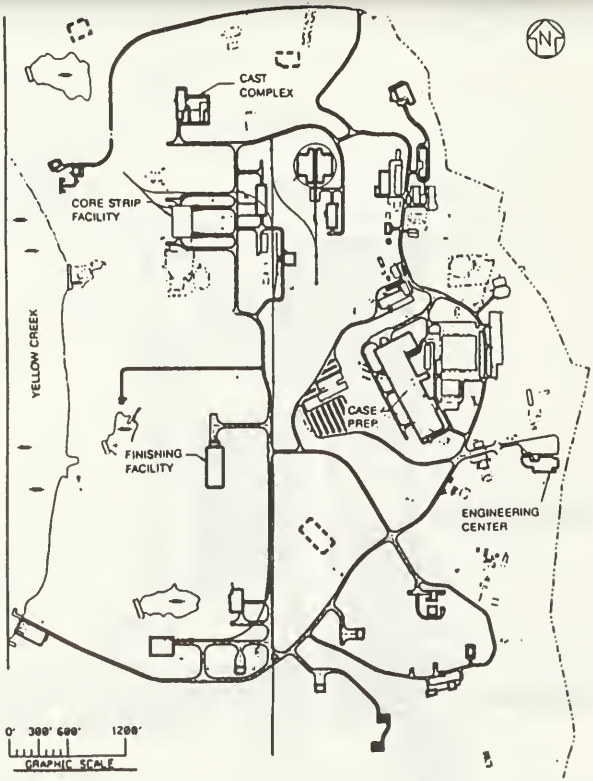
Other equipment to be funded from SFCDC resources is estimated to cost approximately $360 million through completion of development; however, this amount may change as the program matures.

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

The total CoF cost for all ASRM facilities construction at various locations (including CoF-funded equipment procurement) is approximately $574 million. An additional funding increment of approximately $28.2 million is required in FY 1995.

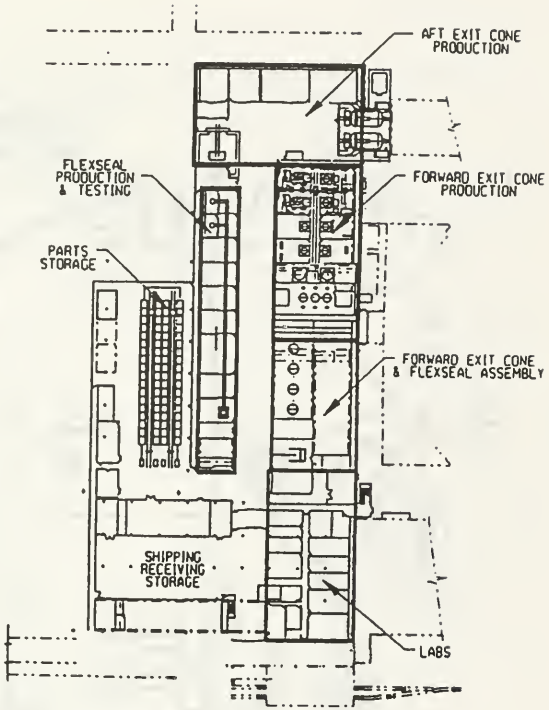
CONSTRUCTION OF
ADVANCED SOLID ROCKET MOTOR FACILITIES
FISCAL YEAR 1994 ESTIMATES
YELLOW CREEK SITE

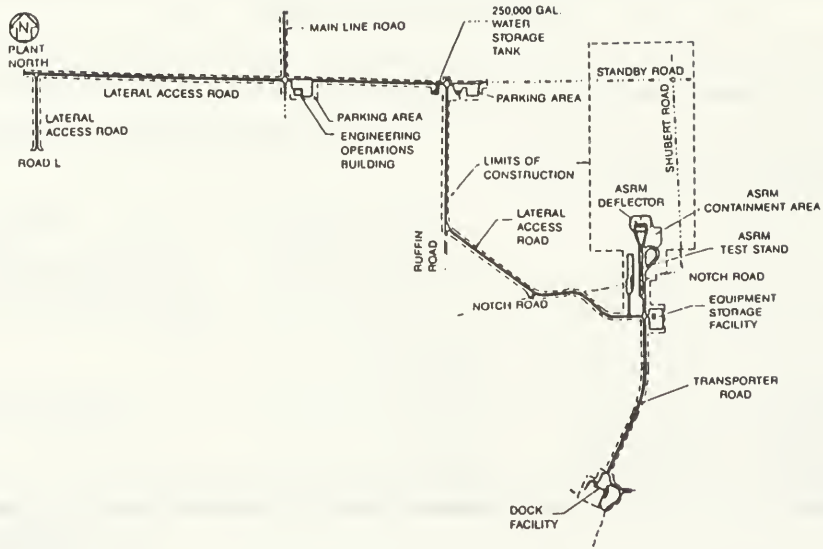
FIGURE 1



CONSTRUCTION OF
ADVANCED SOLID ROCKET MOTOR FACILITIES
FISCAL YEAR 1994 ESTIMATES
MICHOUD NOZZLE MANUFACTURE SITE

FIGURE 2





CONSTRUCTION OF ADVANCED SOLID ROCKET MOTOR FACILITES
FISCAL YEAR 1994 ESTIMATES
STENNIS SPACE CENTER TEST SITE

FIGURE 3

CF 1-50

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
CONSTRUCTION OF FACILITIES
FISCAL YEAR 1994 ESTIMATES

SUMMARY

JOHNSON SPACE CENTER

	Amount (Dollars)	Page No.
Space Flight:		
Rehabilitate Electrical Distribution System, Project Management Building.....	2,200,000	CF 2-1

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1994 ESTIMATES

PROJECT TITLE: Rehabilitate Electrical Distribution System, Project Management Building

INSTALLATION: Lyndon B. Johnson Space Center

FY 1994 CoF Estimate: $2,200,000

LOCATION OF PROJECT: Houston, Harris County, Texas

COGNIZANT HEADQUARTERS OFFICE: Office of Space Flight

FY 1993 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF Funding	$155,855	---	$ 155,855
Capitalized Investment	---	$6,572,314	6,572,314
Total	$155,855	$6,572,314	$6,728,169

SUMMARY PURPOSE AND SCOPE:

The purpose of this project is to replace the existing obsolete and overloaded electrical system that serves the Project Management Building (1). The work includes installing conductors from a new outdoor substation to both ground-floor mechanical rooms and bus ducts to the various floors of the building including the penthouse.

PROJECT JUSTIFICATION:

The electrical substation equipment located in the Building 1 penthouse is 30 years old. Deterioration of the system's electrical insulation, particularly of the dry-type transformers, significantly degrades the reliability of the equipment. Switchgear components are obsolete and

68-668 O—93——19

only limited spare parts are available. The ground-level electrical substation to be provided will be equipped with oil-filled transformers that can be more easily accessed and maintained. With the establishment of a new substation for the building, activation and power cut-over can be accomplished without interrupting normal building operations. In addition, the new substation will provide needed additional electrical capacity to adequately service increased electrical loads in this major building.

IMPACT OF DELAY:

A delay in this project could result in an unscheduled loss of power to this building for several days or weeks, which could require costly emergency repairs and severe interruptions of critical JSC operations.

PROJECT DESCRIPTION:

A new substation will be installed at ground-level adjacent to Building 1. Necessary electrical conductors, switchgear, and panels will be installed. Building electrical distribution and related air-conditioning will be upgraded as required.

PROJECT COST ESTIMATE:	Unit of Measure	Quantity	Unit Cost	Cost
Construction:	---	---	---	$2,200,000
Sitework	LS	---	---	87,300
Demolition	LS	---	---	36,400
Asbestos Removal	LS	---	---	119,700
Mechanical Work	LS	---	---	237,000
Electrical Work	LS	---	---	1,719,600
Total				$2,200,000

LIST OF RELATED GRAPHICS: Figure 1 - Perspective Drawing

OTHER EQUIPMENT SUMMARY: None

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT: None

LYNDON B. JOHNSON SPACE CENTER
FISCAL YEAR 1994 ESTIMATES
REHABILITATE ELECTRICAL DISTRIBUTION SYSTEM,
PROJECT MANAGEMENT BUILDING
PERSPECTIVE DRAWING

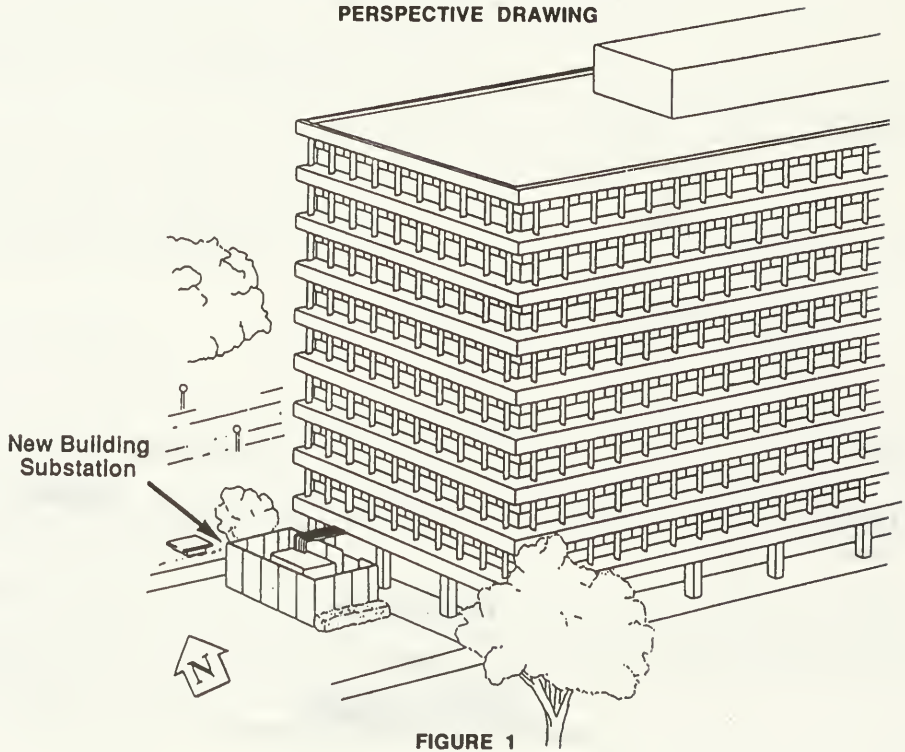


FIGURE 1

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
CONSTRUCTION OF FACILITIES
FISCAL YEAR 1994 ESTIMATES

SUMMARY

KENNEDY SPACE CENTER

	Amount (Dollars)	Page No.
Space Flight:		
Restore Class III Landfill	1,900,000	CF 3-1

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1994 ESTIMATES

PROJECT TITLE: Restore Class III Landfill

INSTALLATION: John F. Kennedy Space Center

FY 1994 CoF Estimate: $1,900,000

LOCATION OF PROJECT: John F. Kennedy Space Center, Brevard County, Florida

COGNIZANT HEADQUARTERS OFFICE: Office of Space Flight

FY 1993 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF Funding	$210,000	---	$210,000
Capitalized Investment	---	---	---
Total	$210,000	---	$210,000

SUMMARY PURPOSE AND SCOPE:

This project provides for restoration of Class III landfill capability by developing a 67 acre site located due east of the Schwartz Road Landfill for this purpose. This landfill is required to accommodate the disposal of non-hazardous debris such as demolition materials, steel, glass, roofing materials, and masonry.

PROJECT JUSTIFICATION:

The present landfill at KSC located on Schwartz Road will soon reach its permitted capacity. On-Center capability is required for disposal of construction debris because off-site disposal would be very costly due to high transportation costs and fees charged by off-site agencies. In addition, off-site disposal could potentially expose NASA to some operational liability should off-site disposal areas become contaminated by other customers.

Cost benefit analyses support restoration of the Class III landfill capability versus off-site disposal. Payback analysis shows a break-even point late in the second year of operation versus hauling off-site. Also, should local off-site disposal sites be closed, KSC would be faced with more distant and more expensive disposal costs.

IMPACT OF DELAY:

The present facility only has capacity to support Center requirements for approximately two more years. This requires restoration of the Class III landfill capability by late calendar year 1993. If this project is not approved, the Center will have to incur additional expensive off-site disposal costs.

PROJECT DESCRIPTION:

This project provides for the development of 67 acres that will be permitted as a Class III landfill. The area will be located at the east end of Schwartz Road due east of the existing Schwartz Road Landfill. Work includes clearing the site for construction of disposal cells, constructing a stabilized access roadway, hauling approximately 200,000 cubic yards of fill dirt to the site for coverage, installing monitoring wells, and constructing a stormwater management system.

PROJECT COST ESTIMATE:	Unit of Measure	Quantity	Unit Cost	Cost
Construction	---	---	---	$1,900,000
Clearing	AC	67	$2,402.99	161,000
Grading	SY	326,000	.35	114,000
Road	SY	1,100	6.36	7,000
Fill	CY	200,200	5.61	1,123,000
Wells	LF	225	66.67	15,000
Stormwater Management .	LS	---	---	250,000
Mitigation	LS	---	---	230,000
Total				$1,900,000

LIST OF RELATED GRAPHICS: Figure 1 - Location Plan

OTHER EQUIPMENT SUMMARY: None

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT: None

JOHN F. KENNEDY SPACE CENTER
FISCAL YEAR 1994 ESTIMATES
RESTORE CLASS III LANDFILL

LOCATION PLAN

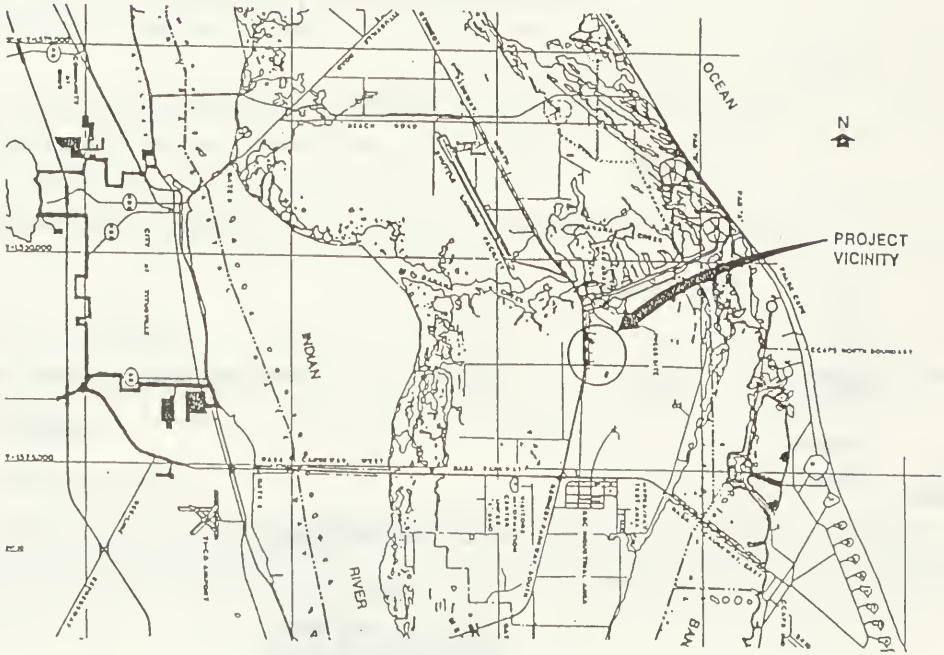


FIGURE 1

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
OFFICE OF MANAGEMENT AND BUDGET
FISCAL YEAR 1994 ESTIMATES
CONSTRUCTION OF FACILITIES

SUMMARY

MARSHALL SPACE FLIGHT CENTER

	Amount (Dollars)	Page No.
Space Flight:		
Restoration of Electrical Power System	2,600,000	CF 4-1

PROJECT TITLE: Restoration of Electrical Power System

INSTALLATION: George C. Marshall Space Flight Center

FY 1994 CoF Estimate: $2,600,000*

*NOTE: This is the NASA portion of a jointly funded NASA/DOD facility project.

LOCATION OF PROJECT: Marshall Space Flight Center, Madison County, Alabama

COGNIZANT HEADQUARTERS OFFICE: Office of Space Flight

FY 1993 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF Funding	$75,000**	---	$75,000
Capitalized Investment	---	---	---
Total	$75,000	---	$75,000

**NOTE: This is the NASA portion of planning and design.

SUMMARY PURPOSE AND SCOPE:

This is a joint project between the Department of the Army and NASA to replace a 45 megavolt amperes (mva) primary electrical power substation at Redstone Arsenal. The Army will fund the cost of replacing the existing substation with one of equal capacity. NASA will fund the cost of augmenting the capacity of the substation by an additional 15 mva. This project is required to support the increasing electrical power needs of NASA programs and to restore overall system reliability.

PROJECT JUSTIFICATION:

The electrical substation to be replaced is owned and maintained by the Army, but primarily serves NASA activities. The substation is over 40 years old and seriously overloaded. It operates continually with cooling fans running, which reduces transformer life and decreases reliability. This is a high risk situation because the substation carries 80 percent of MSFC's total electrical power load. The Army is cognizant of this situation and has budgeted a repair project to replace the substation with one of equal capacity. However, since the existing substation is undersized for the current loads, NASA needs to augment it to avoid a repeat of the current overload condition. This project is critical to ensure the Center has the capability to provide reliable power to support its ongoing test programs, payload mission operations, and research and development activities.

IMPACT OF DELAY:

Delay of this project will impact all programmatic activities at the Center. Failure to augment the substation places operational restrictions on Center programs that substantially increase program costs and cause schedule slips. Continued operation of the primary substation in an overload condition also places the Center at risk of a major electrical brownout or blackout.

PROJECT DESCRIPTION:

This project provides for the purchase and installation of a 15 mva transformer with associated switchgear, circuit breakers, and site work. This equipment will be installed concurrent with the Army's replacement of Primary Substation No. 3. The project also provides for the installation of new 44 kV transmission lines, as required, between the primary substation and NASA secondary substations.

PROJECT COST ESTIMATE:	Unit of Measure	Quantity	Unit Cost	Cost
Construction	---	---	---	$7,600,000
Army Share of Project:				
Three 15 mva transformers with associated site work, switchgear, and 44kV transmission lines to Army secondary substations . . .	LS	---	---	5,000,000
NASA Share of Project:				
One 15 mva transformer with associated site work, switchgear, and 44kV transmission lines to NASA secondary substations . . .	LS	---	---	$2,600,000
Total				$7,600,000

LIST OF RELATED GRAPHICS: Figure 1 - Location Plan

OTHER EQUIPMENT SUMMARY: None

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT: None

MARSHALL SPACE FLIGHT CENTER
FISCAL YEAR 1994 ESTIMATES
RESTORATION OF ELECTRICAL POWER SYSTEM
LOCATION PLAN

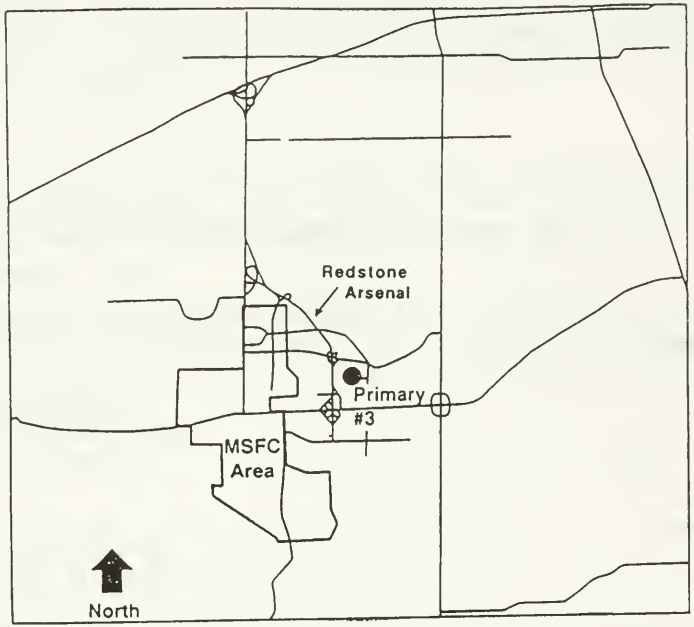


FIGURE 1

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
CONSTRUCTION OF FACILITIES
FISCAL YEAR 1994 ESTIMATES

SUMMARY

STENNIS SPACE CENTER

	Amount (Dollars)	Page No.
Space Flight:		
Restoration of Underground Communication Distribution System.....	3,800,000	CF 5-1

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1994 ESTIMATES

PROJECT TITLE: Restoration of Underground Communication Distribution System

INSTALLATION: John C. Stennis Space Center

FY 1994 CoF Estimate: $3,800,000

LOCATION OF PROJECT: Stennis Space Center, Hancock County, Mississippi

COGNIZANT HEADQUARTERS OFFICE: Office of Space Flight

FY 1993 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF Funding	$537,400	$2,935,000	$3,472,400
Capitalized Investment	---	4,444,060	$4,444,060
Total	$537,400	$7,379,060	$7,916,460

SUMMARY PURPOSE AND SCOPE:

This project provides for the restoration of approximately 10,700 linear feet of underground communication distribution system duct banks in the industrial area of Stennis Space Center (SSC) to restore the reliability of the existing system and to meet future communication requirements in the area.

PROJECT JUSTIFICATION:

The existing underground communication duct bank system along the industrial area route is at maximum capacity. The interior of the duct banks are blocked in many places because the "Orangeburg" (tar impregnated paper) ducts of this old system are swelled shut due to water penetration. Additional duct capacity is critical for providing communication services to the existing and proposed facilities along these routes. Due to the size of the communication cable

required, underground installation is the most cost-effective method. Direct burial of this cable would reduce system flexibility and subject the system to unnecessary risk.

IMPACT OF DELAY:

Delay in the implementation of this project will result in decreased reliability of the existing communication system and the inability to meet future communication requirements along this route.

PROJECT DESCRIPTION:

This project provides for the restoration of 10,700 linear feet of existing underground communication distribution system duct banks in the industrial area of SSC. Also included is an extension to support Building 3202, an extension to support the expansion at the Administrative area, and a branch extending down Propellant Boulevard to the Component Test Facility (CTF). Work includes the construction of double bay manholes, eight feet deep by twelve feet long by six feet wide, placed a minimum of 600 feet apart.

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Cost
Construction	---	---	---	$3,800,000
Sitework	LS	---	---	240,000
Duct Bank	LF	10,700	298.13	3,190,000
Manholes	EA	54	6,851.85	370,000
Total				$3,800,000

LIST OF RELATED GRAPHICS: Figure 1 - Location Plan

OTHER EQUIPMENT SUMMARY: None

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT: None

JOHN C. STENNIS SPACE CENTER
FISCAL YEAR 1994 ESTIMATES
RESTORATION OF UNDERGROUND COMMUNICATION DISTRIBUTION SYSTEM

LOCATION PLAN

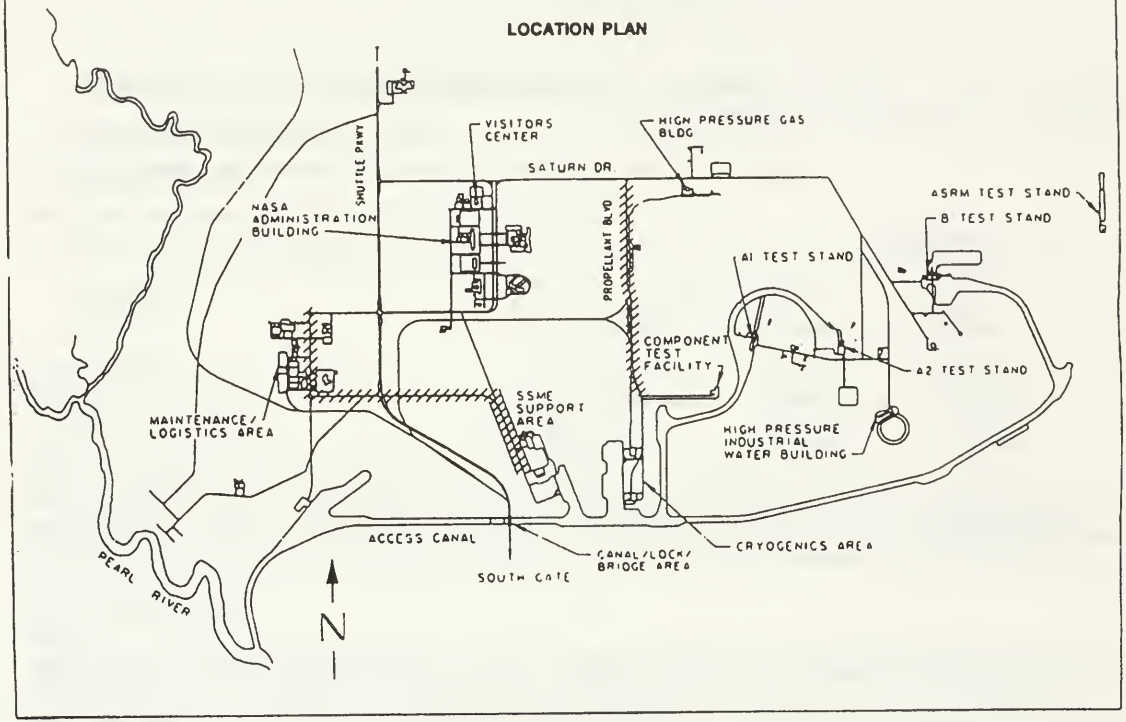


FIGURE 1

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
CONSTRUCTION OF FACILITIES
FISCAL YEAR 1994 ESTIMATES

SUMMARY

GODDARD SPACE FLIGHT CENTER

	Amount (Dollars)	Page No.
Mission To Planet Earth:		
Construction of Earth Systems Science Building	12,000,000	CF 6-1
Replacement of Central Plant Steam and Electrical Generation Equipment	8,600,000	CF 6-5
Restoration and Modernization of Chilled Water System	5,000,000	CF 6-11
Total	25,600,000	

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1994 ESTIMATES

PROJECT TITLE: Construction of Earth Systems Science Building

INSTALLATION: Goddard Space Flight Center

FY 1994 CoF ESTIMATE: $12,000,000

LOCATION OF PROJECT: Greenbelt, Prince George's County, Maryland

COGNIZANT HEADQUARTERS OFFICE: Mission to Planet Earth

FY 1993 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF Funding	$4,849,000	---	$ 4,849,000
Capitalized Investment	---	---	---
Total	$4,849,000	---	$ 4,849,000

SUMMARY PURPOSE AND SCOPE:

This project provides the first increment of an Earth Systems Science Building (ESSB) at the Goddard Space Flight Center (GSFC). The facility will provide approximately 290,000 square feet to house civil service, contractor, and visiting scientist personnel conducting interdisciplinary earth science and research into global change. This facility is located adjacent to the Earth Observing System Data Information System (EOSDIS) Facility and will support the Earth Observing System (EOS) program by data analysis, assimilation, and instrument and algorithm development. The second and third increments to complete the facility are planned for FY 1995 and FY 1996.

PROJECT JUSTIFICATION:

The United States has taken the leadership role in one of the largest Earth Science enterprises--Global Change research. The Earth Observing Systems (EOS) Program is a critical component of this effort. It will contribute principal observational, data processing and archiving, and scientific research capabilities essential to conduct this research. Goddard Space Flight Center is NASA's lead Center for EOS, with the responsibilities for development of Earth Observing

capabilities including responsibility for the Earth Observing System Morning Crossing (EOSAM) and Earth Observing System Afternoon Crossing (EOSPM) spacecraft, GSFC-sponsored NASA facilities class instruments, Earth Science mission operations, and principal or co-investigator responsibilities for a number of EOS-related scientific investigations, as well as Land Remote-Sensing Satellite (LANDSAT), and responsibility for processing, archiving, and disseminating GSFC-related EOS data.

The Earth System Science Building (ESSB) is fundamental to the fulfillment of GSFC EOS/Global Change Science responsibilities. It brings together vital elements of GSFC's substantial Earth Sciences talent in specialized facilities dedicated to the conduct of EOS/Global Change research. Such an arrangement is essential to facilitate and promote the interdisciplinary approach to scientific research required to achieve EOS/Global Change research goals. The ESSB will also provide a venue for collaboration between NASA and other scientists engaged in Global Change research, availing them of the benefits of GSFC's considerable Remote Sensing expertise. The proximity of the ESSB Facility to the EOSDIS Facility will provide ready access to the GSFC EOS Distributed Active Archive Center (DAAC), the central repository (located within the EOSDIS Facility) for all GSFC EOS-related data.

Goddard's Earth Science group is currently located in seven widely separated buildings, creating substantial obstacles to interdisciplinary scientific communication and collaboration, and inefficient EOS Project/EOSDIS programmatic support. The ESSB will create a consolidated environment in which interdisciplinary interactions are fostered not only for the resident GSFC earth scientists but also for visiting scientists. The ESSB also anticipates the need to accommodate new equipment such as computer, workstation, and graphics terminal technologies as they evolve over the life of the EOS/Global Change research effort. This facility will ensure an efficient and productive work environment in which to do EOS/Global Change research.

IMPACT OF DELAY:

If the ESSB facility is delayed, it will adversely impact the analysis and understanding of EOS data, as well as delay the development of instrumentation and algorithms for future earth science missions.

PROJECT DESCRIPTION:

The 290,000 square foot facility will be located on the east site adjacent to the EOSDIS Facility at Greenbelt and Soil Conservation Service Roads. This increment will provide for site development/utilities, and will include extension of basic utilities infrastructure to the ESSB site, expansion of EOSDIS utility plant including provision for backup diesel electric power, and construction of ESSB footings and foundations. The second increment (FY 1995) provides for the ESSB shell and procurement of building architectural, mechanical and electrical long lead items. The third increment (FY 1996) provides for installation of the architectural, mechanical, and electrical long lead items; construction of building interior, partitioning, and finishes; and completion of remaining work to provide a complete and usable facility.

The overall scope of work for this project provides for all necessary site development, including the extension of appropriate Center utility distribution systems (communication duct banks, electrical power, steam, chilled water, sanitary sewer and storm drainage systems), clearing and grubbing, as well as construction of new access roads, necessary parking lots, area lighting, and security fencing and a gate house. Also included is construction of footings and foundations; erection of structural steel; construction of composite concrete and metal floor and roof slabs; construction of exterior walls, doors, windows, and weatherproofing systems; and installation of interior doors, partitions, and finishes. Installation of necessary mechanical and electrical equipment, sized for sufficient capacity to support immediate needs with a modest capacity for future growth, is also included. Appropriate internal building support areas will be provided, including laboratories, loading dock areas, storage spaces, stairs, elevators, restrooms, entrance lobby, fire protection and detection systems, and internal building security systems. Utility control systems, to be tied in with the Center-wide Utility Control System (UCS) monitored from the Central Power Plant, are also included.

PROJECT COST ESTIMATE:	Unit of Measure	Quantity	Unit Cost	Cost
Construction:	---	---	---	$12,000,000
Site Development	LS	---	---	2,100,000
Site Utilities	LS	---	---	2,000,000
Utility Plant Expansion	SF	21,000	214.29	4,500,000
Building Foundations	SF	290,000	11.72	3,400,000
Total				$12,000,000

Note: This cost estimate provides for the FY 1994 increment of the total facility. The total cost of the project is estimated to be approximately $46 million.

LIST OF RELATED GRAPHICS: Figure 1 - Location Plan

OTHER EQUIPMENT SUMMARY:

Noncollateral equipment such as systems furniture, other furnishings, and equipment for special purpose areas will be required at a cost of approximately $20,000,000, which will be provided from other than CoF resources.

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

To complete this project, a second increment will be included in the FY 1995 budget request at $17,000,000 and a third increment in the FY 1996 budget at $17,000,000.

GODDARD SPACE FLIGHT CENTER
FISCAL YEAR 1994 ESTIMATES
CONSTRUCTION OF EARTH SYSTEMS SCIENCE BUILDING (ESSB)

LOCATION PLAN

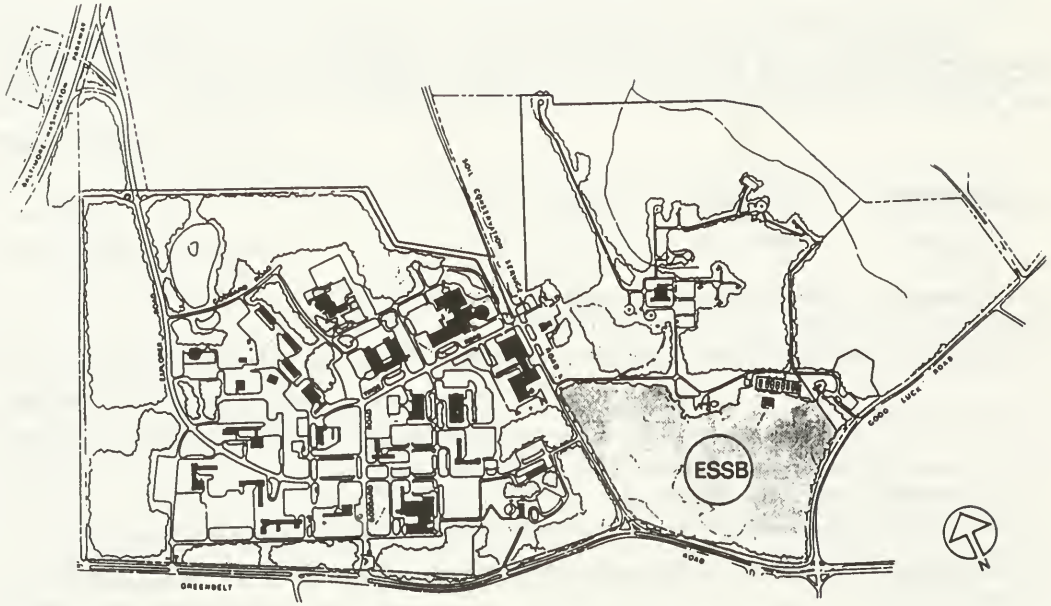


FIGURE 1

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1994 ESTIMATES

PROJECT TITLE: Replacement of Central Plant Steam and Electrical Generation Equipment

INSTALLATION: Goddard Space Flight Center

FY 1994 CoF Estimate: $8,600,000

LOCATION OF PROJECT: Greenbelt, Prince George's County, Maryland

COGNIZANT HEADQUARTERS OFFICE: Mission to Planet Earth

FY 1993 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF Funding	$776,000	---	$ 776,000
Capitalized Investment	---	$5,597,946	5,597,946
Total	$776,000	$5,597,946	$6,373,946

SUMMARY PURPOSE AND SCOPE:

This project provides for the replacement of 25- to 30-year-old steam generation equipment and emergency diesel generator sets located in the Central Heating and Cooling Plant, Building 24, with three new 40,000 lb/hr. dual fuel, water-tube boilers and five new 1,000 KW diesel-generator sets. The project will also provide for the construction of an addition to the existing generator building (24C) to house the new diesel generators and associated equipment.

PROJECT JUSTIFICATION:

This project will replace current steam and electrical generation capability in Building 24. Steam boilers and diesel generator sets are 25 to 30 years old, and are nearing the end of their service life. The central steam plant is required to provide steam to all major buildings for heating, hot water and humidification. Diesel generator sets are required to provide emergency backup power to mission critical facilities. Due to equipment age, replacement parts are not readily available. Currently, Building 24 houses five boilers with a combined capacity of 158,000 pounds per hour. The existing diesel generator capacity consists of four 500 KW generators in the basement of Building 24 and three 500 KW generators in Building 24C. The project is a key element of ongoing efforts to restore the Center's utilities infrastructure before serious and disruptive equipment breakdowns occur.

IMPACT OF DELAY:

Deferral will increase the probability of boiler and diesel generator failures and increase maintenance downtime, reducing plant reliability for meeting steam and back-up power requirements for mission support.

PROJECT DESCRIPTION:

This project provides for removal of four steam, water-tube boilers with combined capacity of 123,000 pounds per hour; removal of ancillary equipment associated with each boiler, as required; removal of all asbestos material within scope of construction and replacement with non-asbestos material, as required; and removal of existing diesel-generator sets, associated switchgear, controls and cabling from the basement of Building 24.

Replacement steam generation equipment will consist of three dual fuel (natural gas/#2 fuel oil) water-tube boilers with a capacity of 40,000 lb/hr, each. The new equipment will be designed to use #2 fuel oil as a back-up fuel source. Also included are upgrades and structural modifications to accommodate new equipment and to retain boiler No. 6 as a back-up unit. Conversion of burner and pneumatic controls on Boiler No. 6 and fuel system modifications to permit use of #2 fuel oil are also included. In addition, the project provides five 1,000 KW diesel-generator sets to replace existing diesel equipment in the basement of Building 24, and to accommodate current and known growth in emergency power requirements. The project also provides for an addition to the generator Building 24C to house the new generators and associated equipment. The project also includes conversion of the diesel equipment room in the basement of Building 24 to a storeroom.

PROJECT COST ESTIMATE:	Unit of Measure	Quantity	Unit Cost	Cost
Construction	---	---	---	$8,600,000
Boiler Replacement	LS	---	---	4,600,000
Diesel Replacement	LS	---	---	$4,000,000
Total				$8,600,000

LIST OF RELATED GRAPHICS: Figure 1 - Location Plan
Figure 2 - Proposed Boiler Plant Layout
Figure 3 - Proposed Diesel Plant Layout

OTHER EQUIPMENT SUMMARY: None

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT: None

GODDARD SPACE FLIGHT CENTER
FISCAL YEAR 1994 ESTIMATES
REPLACEMENT OF CENTRAL PLANT STEAM AND ELECTRICAL GENERATION EQUIPMENT

LOCATION PLAN

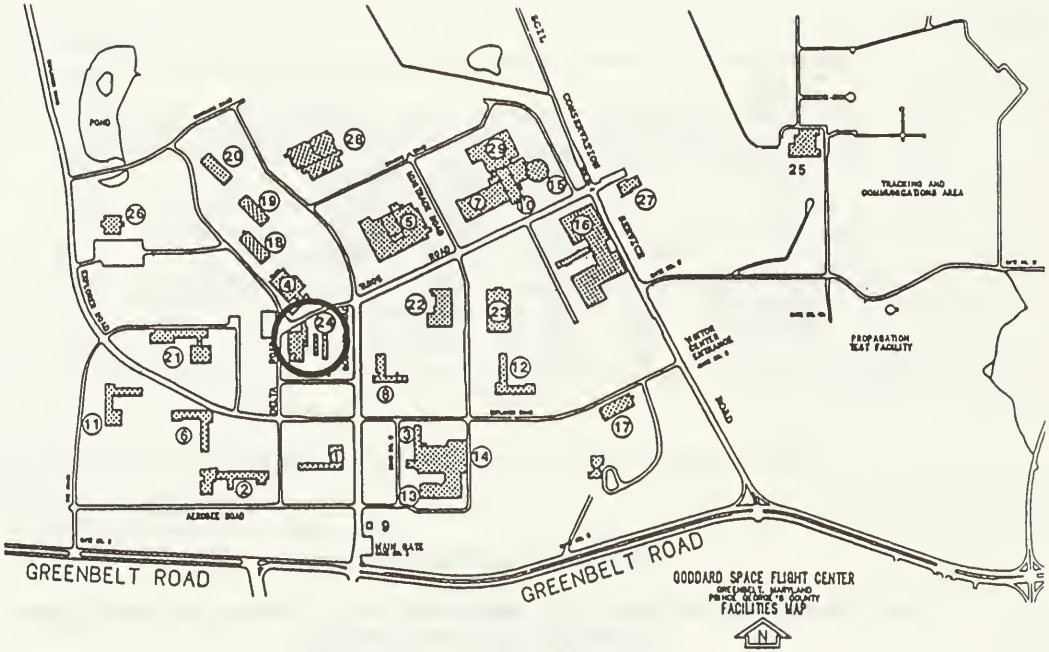
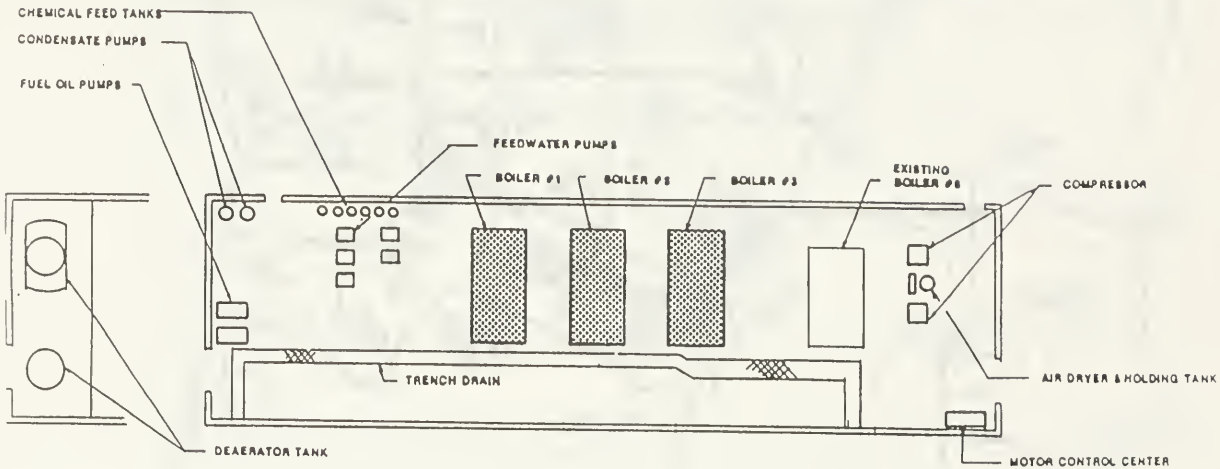


FIGURE 1

CF 6-8

GODDARD SPACE FLIGHT CENTER
FISCAL YEAR 1994 ESTIMATES
REPLACEMENT OF CENTRAL PLANT STEAM AND ELECTRICAL GENERATION EQUIPMENT

PROPOSED BOILER PLANT LAYOUT



NEW 40,000 LB/HR BOILERS

FIGURE 2

GODDARD SPACE FLIGHT CENTER
FISCAL YEAR 1994 ESTIMATES
REPLACEMENT OF CENTRAL PLANT STEAM AND ELECTRICAL GENERATION EQUIPMENT

PROPOSED DIESEL PLANT LAYOUT

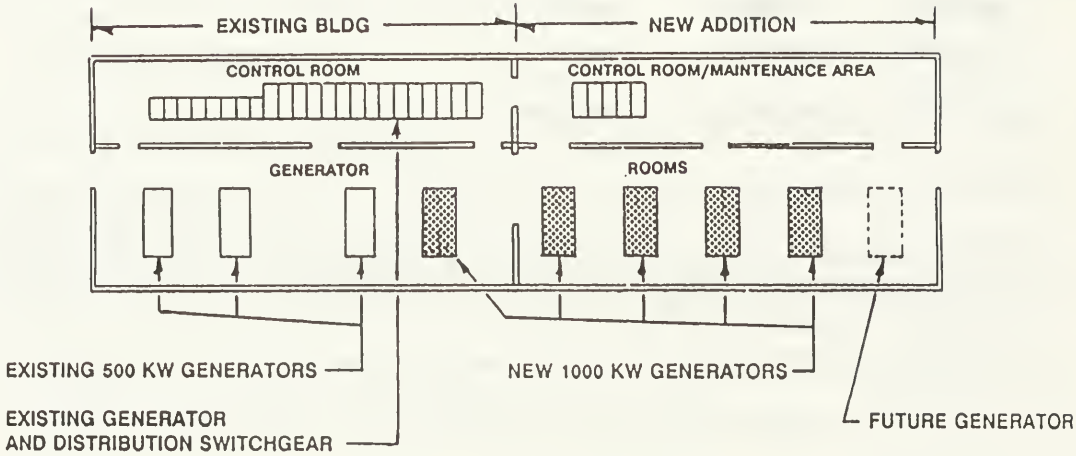


FIGURE 3

CF 6-10

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1994 ESTIMATES

PROJECT TITLE: Restoration and Modernization of Chilled Water System

INSTALLATION: Goddard Space Flight Center

FY 1994 CoF ESTIMATE: $5,000,000

LOCATION OF PROJECT: Greenbelt, Prince George's County, Maryland

COGNIZANT HEADQUARTERS OFFICE: Mission to Planet Earth

FY 1993 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF Funding	$475,000	---	$ 475,000
Capitalized Investment	---	$3,874,500	3,874,500
Total	$475,000	$3,874,500	$ 4,349,500

SUMMARY PURPOSE AND SCOPE:

This project provides for the restoration and modernization of the Center's central chilled water system. The project consists of the replacement of chiller #8 (3,000 ton unit) at the central plant, the upgrade of the central plant chilled water pumping system, and the replacement/upgrade of the site chilled water distribution piping system.

PROJECT JUSTIFICATION:

Chiller #8 is approximately 20 years old and is increasingly difficult to maintain because of a limited availability of replacement parts. The current chilled water pumping configuration reflects old design technology. The system is inefficient and difficult to control and operate. The central plant has a capacity of 10,500 tons. Activation of facilities currently under construction is expected to increase the load to 10,500 tons. The only backup will then be Chiller #8. The age and condition of Chiller #8 places it at high risk of failure with a prolonged down-time. Consequently, there is a high probability that loss of a second chiller due to failure or required maintenance would result in the inability of the plant to support a peak-load condition, thus requiring load sheading. Distribution system lines are old and at increased risk of failure, which could result in loss of cooling to critical operational areas. Systematic replacement and upgrade of the central chilled water distribution system is required to minimize the risk associated with distribution system failure. Modifications will also increase the energy efficiency and performance of the plant.

IMPACT OF DELAY:

Delay of the project will increase the risk of equipment and line distribution system failure, leading to a requirement for load sheading, which will have a very negative impact on Goddard's programmatic/institutional operations.

PROJECT DESCRIPTION:

This project provides for the replacement of Chiller #8 with a new 3,000 ton unit; upgrading of the center chilled water pumping system and installation of new pumps in the central plant to hydraulically isolate the chiller loop and the distribution loop; and replacement of portions of the site distribution system piping to include removal of deteriorated and undersized pipe sections and balancing of chilled water systems to all buildings.

Asbestos insulation on existing piping shall be removed to the extent that it is necessary to perform the work. All asbestos work shall conform to Environmental Protection Agency (EPA) and Occupational Safety and Health Administration (OSHA) regulations.

PROJECT COST ESTIMATE:	Unit of Measure	Quantity	Unit Cost	Cost
Construction:	---	---	---	$5,000,000
Chiller Replacement	LS	---	---	2,500,000
Upgrade Chilled Water Pump System	LS	---	---	1,500,000
Replace Distribution Piping . . .	LS	---	---	1,000,000
Total				$5,000,000

LIST OF RELATED GRAPHICS: Figure 1 - Location Plan
Figure 2 - Proposed Chiller Plant Layout

OTHER EQUIPMENT SUMMARY: None

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT: None

GODDARD SPACE FLIGHT CENTER
FISCAL YEAR 1994 ESTIMATES
RESTORATION AND MODERNIZATION OF CHILLED WATER SYSTEM

LOCATION PLAN

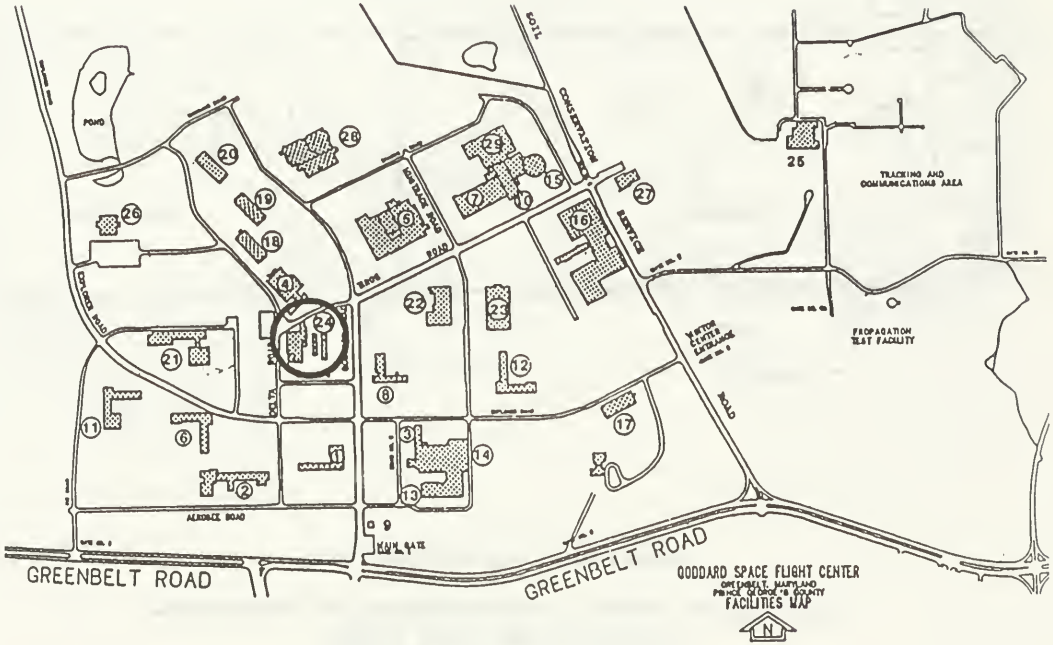


FIGURE 1

GODDARD SPACE FLIGHT CENTER
FISCAL YEAR 1994 ESTIMATES
RESTORATION AND MODERNIZATION OF CHILLED WATER SYSTEM

PROPOSED CHILLER PLANT LAYOUT

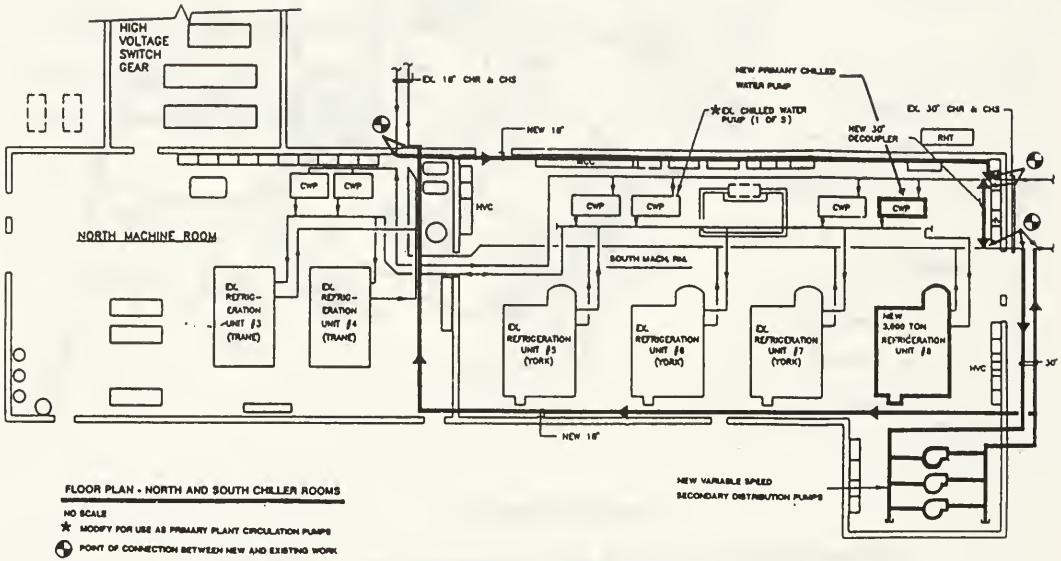


FIGURE 2

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
CONSTRUCTION OF FACILITIES
FISCAL YEAR 1994 ESTIMATES

SUMMARY

JET PROPULSION LABORATORY

	Amount (Dollars)	Page No.
Space Science:		
Modifications to Cooling Systems, Various Buildings	2,900,000	CF 7-1

68-668 O—93——20

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1994 ESTIMATES

PROJECT TITLE: Modifications to Cooling Systems, Various Buildings

INSTALLATION: Jet Propulsion Laboratory

FY 1994 CoF Estimate: $2,900,000

LOCATION OF PROJECT: La Canada-Flintridge, Los Angeles County, California

COGNIZANT HEADQUARTERS OFFICE: Office of Space Science

FY 1993 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project.

	Planning and Design	Construction	Total
Specific CoF Funding	$ 214,000	---	$ 214,000
Capitalized Investment	---	$14,032,883	14,032,883
Total	$ 214,000	$14,032,883	$14,246,883

SUMMARY PURPOSE AND SCOPE:

The project will replace eight obsolete air conditioning water chillers with five state-of-the-art chillers. This will eliminate the need to obtain expensive hand-made replacement parts and use ozone depleting refrigerants. Replacement of high maintenance, obsolete equipment with modern efficient machines using environmentally acceptable refrigerants will provide the laboratory with additional cooling capacity and lower operating and maintenance costs.

PROJECT JUSTIFICATION:

The project will remove chillers that are decades old, beyond their economic lives, unreliable, inefficient and very difficult and expensive to maintain. Repair parts are very difficult or impossible to obtain. The chillers use environmentally unacceptable refrigerant. Chiller replacement will allow the use of non-ozone depleting refrigerants. The replacement chillers in Buildings 168 and 169 will be sized to accommodate additional cooling loads anticipated for new adjacent facilities, thereby saving construction funds and equipment space. The chillers to be removed from Building 126 are thirty to forty years old and cannot handle occasional low cooling requirements. The new chiller in Building 238 will be able to accommodate the occasional low cooling requirements for both buildings and eliminate three very high maintenance cost refrigeration units.

IMPACT OF DELAY:

If this project is not approved, inefficient and costly operation of the obsolete chillers will continue at Buildings 125, 126, 168, 169 and 238. It will impede JPL's ability to provide needed cooling for personnel and equipment, and repairs will be required with increased frequency. The new chillers will use environmentally acceptable refrigerants and save significant cost to bring the old existing units into compliance with California environmental laws.

PROJECT DESCRIPTION:

The project will remove eight chillers from four buildings. Two chillers from Building 125 will be replaced with a single 225-ton chiller, the primary chilled water pump will be increased to match the higher total tonnage and new higher capacity condenser water pumps will be provided. Two 25-year-old water chillers (110-tons each) in Building 168 and one 18-year-old water chiller (140-ton) in Building 169 will be replaced with larger (225-ton), more efficient machines. This will compensate for the increased cooling loads in Buildings 168, 169, and 186. Three small, aging chillers will be removed from Building 126, a 200-ton water chiller will be added to the adjacent Building 238, a new primary-secondary chilled water pumping arrangement will be added to Building 238, and Building 126 cooling requirements will be serviced by the secondary loop from Building 238. This project will also modify the controls and chilled water piping in Building 126. The existing 6" condenser water line serving the Building 126 chillers will be converted to chilled water service by insulating and re-supporting the pipe runs. The existing 10-inch condenser water mains to Building 238 will be changed out to 12-inch lines to handle the additional 200-ton chiller.

In all cases, allowances have been made for temporary mounted chillers connected with fire hoses for cooling during periods of removal and re-installation of chillers.

PROJECT COST ESTIMATE:	Unit of Measure	Quantity	Unit Cost	Cost
Construction:	---	---	---	$2,900,000
Mechanical	LS	---	---	2,400,000
Electrical	LS	---	---	500,000
Total				$2,900,000

LIST OF RELATED GRAPHICS: Figure 1 - Location Plan
Figure 2 - Schematics

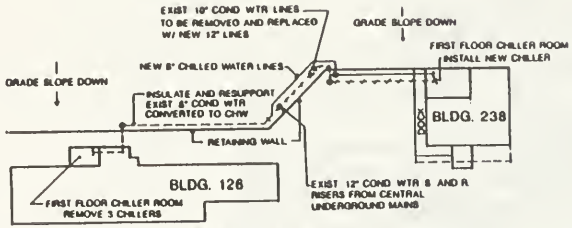
OTHER EQUIPMENT SUMMARY: None

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT: None

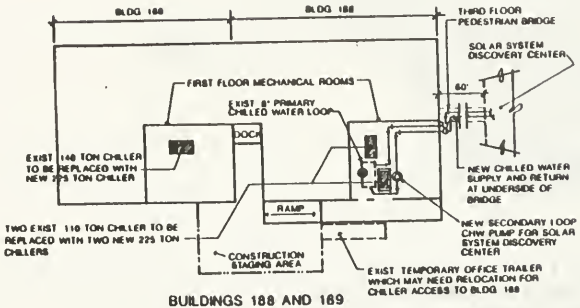
JET PROPULSION LABORATORY
FISCSL YEAR 1994 ESTIMATES
MODIFICATIONS TO COOLING SYSTEMS, VARIOUS BUILDINGS
LOCATION PLAN

FIGURE 1

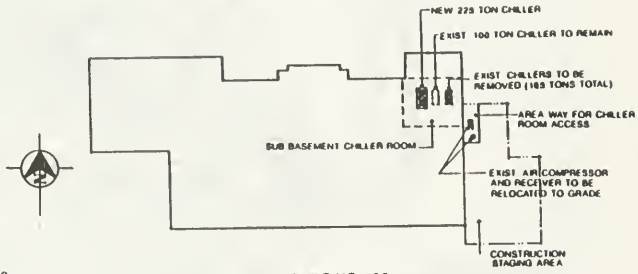
JET PROPULSION LABORATORY
FISCAL YEAR 1994 ESTIMATES
MODIFICATIONS TO COOLING SYSTEMS, VARIOUS BUILDINGS
SCHEMATICS



BUILDINGS 126 AND 236



BUILDINGS 188 AND 189



BUILDING 125

FIGURE 2

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
CONSTRUCTION OF FACILITIES
FISCAL YEAR 1994 ESTIMATES

SUMMARY

WALLOPS FLIGHT FACILITY

	Amount (Dollars)	Page No.
Mission To Planet Earth:		
Restoration of Airfield	5,200,000	CF 8-1

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1994 ESTIMATES

PROJECT TITLE: Restoration of Airfield

INSTALLATION: Wallops Flight Facility

FY 1994 CoF Estimate: $5,200,000

LOCATION OF PROJECT: Wallops Island, Accomack County, Virginia

COGNIZANT HEADQUARTERS OFFICE: Mission to Planet Earth

FY 1993 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF Funding	$300,000	$ -----	$ 300,000
Capitalized Investment	---	35,828,914	35,828,914
Total	$300,000	$35,828,914	$36,128,914

SUMMARY PURPOSE AND SCOPE:

This project provides for the restoration of airfield runways, taxiways, drainage structures/systems, aprons, including the installation of separate controls for the Precision Approach Path Indicator (PAPI) and Runway End Identification Light (REIL) systems on each of the airfield runways and the construction of a 6,000 foot road around the approach to Runway 10/28.

PROJECT JUSTIFICATION:

Wallops Flight Facility (WFF) is a flight testing facility with elaborate tracking and data systems. The sparsely populated area has a low-density, 5-mile air traffic control zone. This ideal research airfield has been utilized for an average of 180 test periods per year. Each test period involves from one to four hours of tracking and data system activation and from 1 to 30 aircraft movements. This level of utilization is expected for the indefinite future.

All three runways and supporting taxiways and aprons must be maintained in an operational status to provide a high level of safety, flexibility in normal operations, and efficient crosswind research. All runways must be available for use in adverse wind or other weather conditions. The taxiways must also be maintained in an operational status to provide the full capability to conduct multiaircraft operations.

At the present time, in order to operate the PAPI system during daylight hours, the runway lights must be turned on, wasting large amounts of electrical energy. The REIL systems on Runways 10-28 and 17-35 will operate only when the runway edge lights are set very bright. This creates a glare problem to aircraft pilots. The existing airfield lighting vault is too small to accommodate the needed new equipment to correct these problems.

The construction of the road around the runway approach will eliminate the safety hazard of directly crossing the runway.

IMPACT OF DELAY:

Delay of this project will cause accelerated deterioration of the existing airfield surfaces, make the airfield less safe for aircraft operations, more costly to repair in the future, and will increase the risk to future aircraft research flights.

PROJECT DESCRIPTION:

This project will provide for the repair of Runways 17/35 and 10/28, taxiways, aprons, drainage structure/systems, which consists of surface milling; placement of bituminous concrete over existing bituminous concrete surfaces only; cleaning and resealing of cracks in bituminous concrete; placements of a fabric reinforced system for crack control; restriping; repair of rigid pavement surfaces; the routing, cleaning, and resealing of joints, cracks, and spalls; and the construction of drainage structures/systems adjacent to pavement edges. The PAPI and REIL Systems work consists of the installation of 85,000 linear feet of 5,000 volt airfield lighting cable, 25,000 linear feet of bare copper cable, 3-4KW regulators, a 235 square foot addition to the airfield lighting vault, and new brightness controls for the PAPI systems. The road work consists of excavation, drainage, and the placement of crusher run and surface treatment necessary for the construction of a 6,000 foot road around the approach to Runway 10/28.

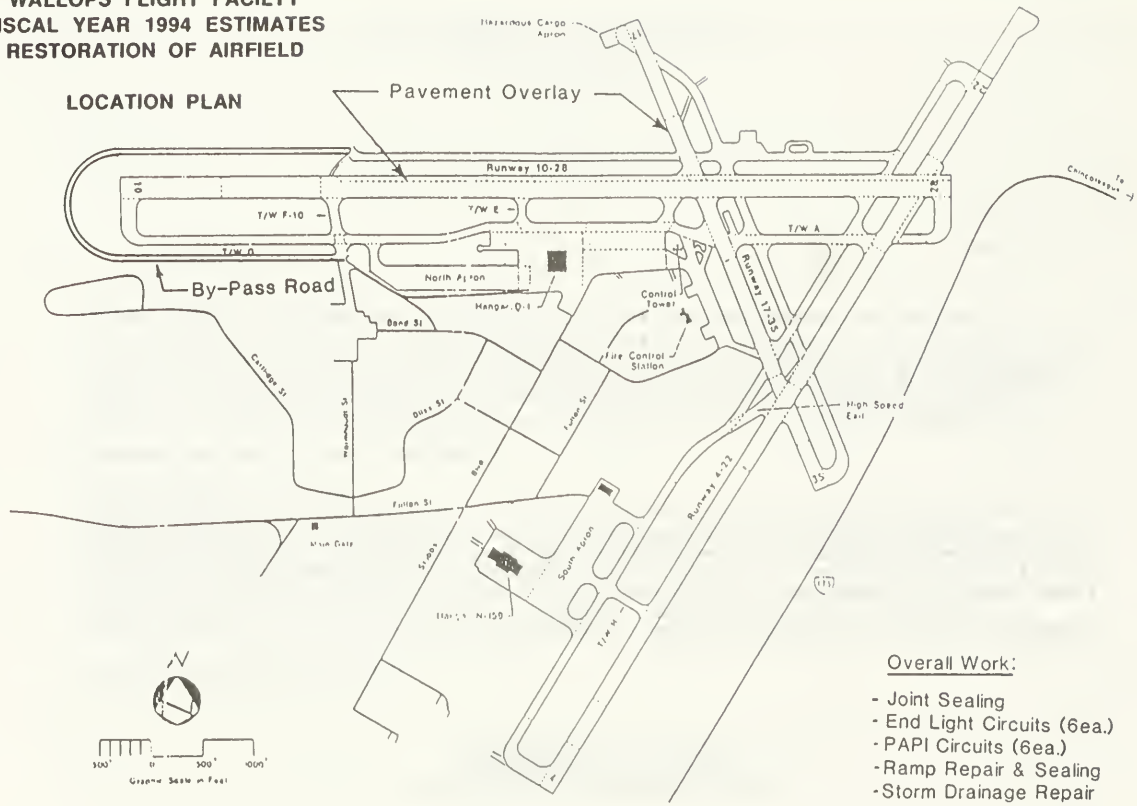
PROJECT COST ESTIMATE:	Unit of Measure	Quantity	Unit Cost	Cost
Construction:	---	---	---	$5,200,000
Pavement Repair and Sealing	LS	---	---	3,250,000
Pavement Overlay	LS	---	---	690,000
Restriping Pavement	LS	---	---	160,000
Storm Drainage Structure Repair	LS	---	---	220,000
By-Pass Road Construction	LS	---	---	530,000
Lighting System Modifications	LS	---	---	350,000
Total				$5,200,000

LIST OF RELATED GRAPHICS: Figure 1 - Location Plan

FUTURE ESTIMATED CoF FUNDING REQUIRED TO COMPLETE THIS PROJECT: None

WALLOPS FLIGHT FACILTY
FISCAL YEAR 1994 ESTIMATES
RESTORATION OF AIRFIELD

LOCATION PLAN



Overall Work:

- Joint Sealing
- End Light Circuits (6ea.)
- PAPI Circuits (6ea.)
- Ramp Repair & Sealing
- Storm Drainage Repair

FIGURE 1

CF 8-4

Aeronautics Facilities Upgrade

The FY 1994 CoF Budget significantly augments the National Aeronautics Facilities Upgrade Program which was initiated in FY 1993. The major thrust of this program is the identification and construction of aeronautical research and development facilities needed to enhance the United States' competitive advantage in the world aeronautics markets. To support this effort, the National Facilities Study is making a critical review of present and future facility requirements. This will determine the high priority capabilities that are needed to lead us into the next century. This program will provide the resources to develop that capability.

Aeronautical Facilities Revitalization

In FY 1994, this program provides for the rehabilitating of the control systems in the National Full-Scale Aerodynamics Complex, upgrading the Outdoor Aerodynamic Research Facility, and the modernization of the Unitary Plan Wind Tunnel Complex at Ames Research Center. The Unitary Plan Wind Tunnel Complex is the final project in this revitalization program begun in FY 1988. It will require $30 million in FY 1995 to complete its modernization to improve productivity, reliability, and quality of test results.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
CONSTRUCTION OF FACILITIES
FISCAL YEAR 1994 ESTIMATES

SUMMARY

NATIONAL AERONAUTICS FACILITIES UPGRADE PROGRAM

	Amount (Dollars)	Page No.
Aeronautics:		
National Aeronautics Facilities Upgrade Program	181,000,000	CF 9A-1

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1994 ESTIMATES

PROJECT TITLE: National Aeronautics Facilities Upgrade Program

INSTALLATION: Various Locations

FY 1994 CoF Estimate: $181,000,000

LOCATION OF PROJECT: Various Locations

COGNIZANT HEADQUARTERS OFFICE: Office of Aeronautics

FY 1993 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF Funding	$330,000	$ 25,000,000	$ 25,330,000
Capitalized Investment	---	172,743,241	172,743,241
Total	$330,000	$197,743,241	$198,073,241

SUMMARY PURPOSE AND SCOPE:

This program continues an effort begun in FY 1993 to upgrade the United States aeronautics facilities capability. The United States has been increasingly challenged in world aeronautics markets for some time. Since 1984, its share of those markets has dropped with a corresponding loss of numerous aerospace jobs. It is important that this trend be reversed. The new Administration seeks to infuse the United States' aerospace industry with the capability to develop a new generation of civil and military aircraft which will outperform the international competition at comparable or lower cost. This program will contribute to that goal by providing the high priority facilities needed to develop a significant portion of the required advanced aeronautical technology.

PROJECT JUSTIFICATION:

Ground test facilities play an essential role in the process of bringing an aircraft from the concept stage to finished product. One of the reasons our nation had been so preeminent in aeronautics in the past is that our ground test facilities were the finest in the world. However, today some foreign wind tunnels, for instance, have greater capability and higher productivity than their U.S. counterparts. Some of our facilities can no longer satisfy industry's needs to the degree they once did. New and upgraded wind tunnels and other related test facilities are required to enhance industry's ability to develop and bring to market the next generation of significantly more competitive U.S. aircraft.

Presently, the average age of U.S. wind tunnels is about 40 years. In addition, certain composite materials testing facilities have become inadequate. Some tunnels have testing backlogs of up to 2 years due to low productivity. Reynolds Numbers and flow conditions fall short of those needed for some next generation aircraft, especially for development of new large aircraft. Tunnel acoustic measuring conditions also need improvement. These testing capabilities are essential in the development of environmentally compatible future aircraft. For example, high Reynolds Number testing capability is essential to assess problems such as laminar flow control, high lift device design, and adaptive wing configurations. These problems cannot be adequately simulated in current test facilities.

This program aims to provide the essential upgrades and new test facilities that are determined to be needed for the U.S. to maintain its preeminence in aeronautics. The program that is developed will be a consequence of the on-going National Facility Study and other similar studies.

IMPACT OF DELAY:

Delay in this program would allow foreign competitors to enhance their relative position in quality of research facilities, which could assist development of foreign aircraft which exceed the capability of those manufactured in the U.S.

DESCRIPTION OF WORK:

The essential elements of this project are:

Acoustic modifications to the 40 x 80 wind tunnel at Ames Research Center: This tunnel will provide the only large-scale aeroacoustic testing capability in the United States in direct support of the high speed civil transport program. It is essential to the development and testing of large-scale Phase II engine and suppressors for validation of integrated noise suppression in takeoff and climbout prior to flight. It will provide a world class capability by creating the largest quiet, anechoic wind tunnel in the world, with a test section capable of

full-scale and large-scale test up to maximum test section velocities of Mach 0.45. The project includes: a new 42-inch deep test section acoustic lining; a new variable-speed and variable-pitch control for the fan drive; acoustic treatment at critical locations of tunnel sidewalls; and other supporting upgrades of auxiliary systems.

Facility studies, definition of requirements, design, and construction of a new or drastically modified set of U.S. wind tunnels: This will be initiated on the most urgent facility needs identified in the National Facility Study. Preliminary results of the National Facility Study clearly indicate a need to construct new high productivity, state-of-the-art subsonic and transonic wind tunnels and upgrade existing tunnels. Deactivation of some existing unproductive facilities is also being investigated. It is imperative that funds be available to begin this effort in FY 1994 in order to minimize the lead time needed for facilities upgrades and construction.

Modifications for Composite Technology Center, Lewis Research Center: Research in advanced composite materials is important in the development of the lowest weight, most fuel-efficient next generation aircraft. This research is also critical for development of high-temperature aerospace propulsion and power systems. Current research programs, such as High Speed Research and advanced rockets require research in light, high temperature composites to enable low weight, long life systems. Providing this integrated facility for composite characterization and research in fabrication processing guided by modelling will shorten the development cycle for each key material for propulsion and power systems. The existing Materials and Structures Building is severely deteriorated and is inadequate for modern advanced composite materials development. This project will construct an addition of approximately 45,000 square feet to the building for composite materials and chemical analysis laboratories. The existing 45-year-old building will be modified to improve life and environmental safety and to improve efficiency of building systems.

National Transonic Facility (NTF) Productivity Enhancement, Langley Research Center: Provides for modifications to nitrogen supply/exhaust system; drive control; and data acquisition rate. Currently the nitrogen system at the NTF not only constrains the potential productivity but also directly impacts the cost of data. Providing increased liquid nitrogen storage in the upgraded liquid nitrogen system and installing a heater on the vent stack will reduce interruptions in the desired flow of a test program. The NTF and 16-Foot Transonic Tunnel share a 40-year-old drive control system; this system has caused significant NTF downtimes because of breakdowns. New equipment is required to provide NTF with its own drive control and to allow both of these major facilities to run simultaneously. Increasing the data acquisition rate at NTF will require new automatic control system algorithms to allow fast model attitude changes while maintaining test conditions. A new model preparation area will also be provided.

Performance Improvements in 11-Foot Wind Tunnel, Ames Research Center: To improve the modeling capabilities of this facility, the Reynolds Number test parameter of the Ames Unitary Plan 11-by 11-Foot Transonic Wind Tunnel must be increased. Reynolds Number for full-span models may be increased from about 10 million to about 16 million by fully utilizing the existing pressure shell capability and automated adaptive test section walls to allow larger model sizes. Tunnel internals will be modified to withstand increased pressures. This element provides new capability (60% increase in Reynolds Number) not budgeted as part of the ongoing FY 93-95 program to modernize the Unitary Plan Wind Tunnel of which the 11- by 11-Foot Transonic Wind Tunnel is a part.

FY 1994 PROJECT COST ESTIMATE:

The preliminary cost estimates are based on initial estimates of studies, requirements definition analyses, designs, and construction or modification of other facilities. As the National Facility Plan matures, recommendations are validated and refined, and studies progress, revisions, additions and/or deletions to facilities requirements and estimated costs may be necessary.

	FY 1993	FY 1994
Acoustic Modifications to 40 X 80 Wind Tunnel (ARC)	$25,000,000	---
Facility Studies, Requirements Definition, Design, and Modification and Construction of National Aeronautics Facilities, Various Locations	---	$74,000,000
Modifications for Composite Technology Center (LeRC)	---	27,000,000
National Transonic Facility Productivity Enhancement (LaRC)	---	60,000,000
Performance Improvements in 11-Foot Wind Tunnel (ARC)	---	20,000,000
Total	$25,000,000	$181,000,000

LIST OF RELATED GRAPHICS: Figure 1 - Perspective of Composite Technology Center

OTHER EQUIPMENT SUMMARY: Research and Development Funding in the amount of $19,000,000 has been identified to support research on components, pilot models, instrumentation, and other items.

FUTURE CoF FUNDING REQUIRED TO COMPLETE THIS PROJECT: To continue this effort, significant additional resources may be required in subsequent fiscal years for new state-of-the-art facilities identified in the completed National Facility Study.

LEWIS RESEARCH CENTER
FISCAL YEAR 1994 ESTIMATES
MODIFICATIONS FOR COMPOSITE TECHNOLOGY CENTER

PERSPECTIVE

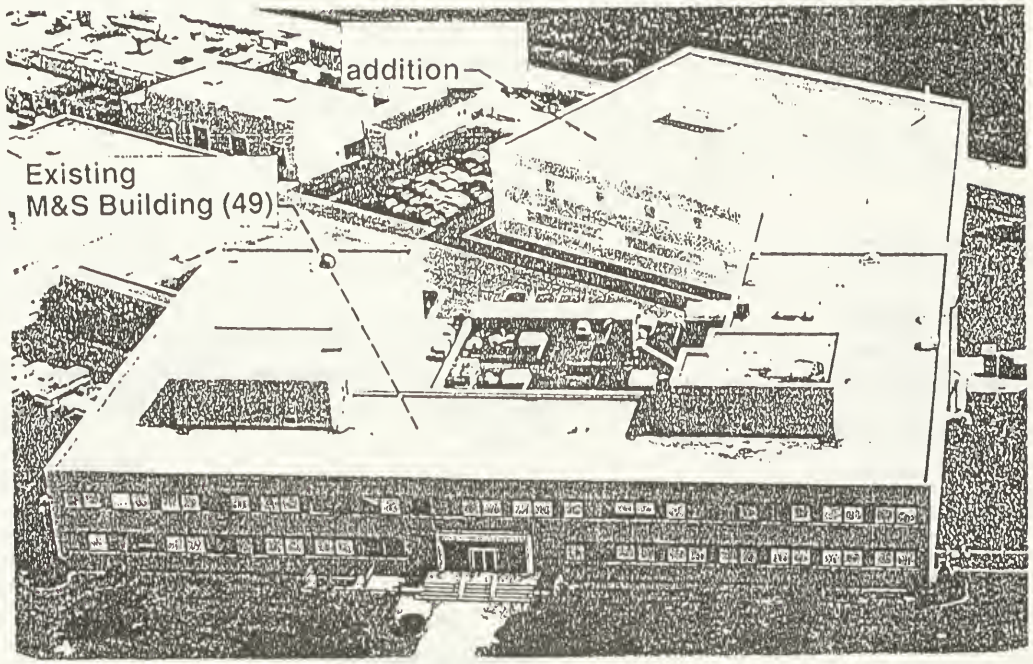


FIGURE 1

CF 9A-6

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
CONSTRUCTION OF FACILITIES
FISCAL YEAR 1994 ESTIMATES

SUMMARY

AERONAUTICAL FACILITIES REVITALIZATION

	Amount (Dollars)	Page No.
Aeronautics:		
Rehabilitation of Control Systems, National Full-Scale Aerodynamics Complex, Ames Research Center	2,100,000	CF 9B-1
Upgrade of Outdoor Aerodynamic Research Facility, Ames Research Center	3,900,000	CF 9B-6
Modernization of the Unitary Plan Wind Tunnel Complex, Ames Research Center	25,000,000	CF 9B-11
Total	31,000,000	

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1994 ESTIMATES

PROJECT TITLE: Rehabilitation of Control Systems, National Full-Scale Aerodynamics Complex

INSTALLATION: Ames Research Center

FY 1994 CoF Estimate: $2,100,000

LOCATION OF PROJECT: Moffett Field, Santa Clara County, California

COGNIZANT HEADQUARTERS OFFICE: Office of Aeronautics

FY 1993 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project.

	Planning and Design	Construction	Total
Specific CoF Funding	$208,000	---	$ 208,000
Capitalized Investment	---	$143,892,370	143,892,370
Total	$208,000	$143,892,370	$144,100,370

SUMMARY PURPOSE AND SCOPE:

This project will replace the control systems for the model support systems in the 40 by 80 and 80 by 120 foot legs of the National Full-Scale Aerodynamics Complex (NFAC) with current technology distributed control systems that will improve the operation of this valuable national resource. This project is included in the Aeronautical Facilitiies Revitalization Program.

PROJECT JUSTIFICATION:

This project is required to replace obsolete and inefficient control systems in the NFAC. This wind tunnel complex provides aerodynamic results vital to United States commercial and defense aeronautical programs. The present model support hardware was designed over ten years ago and uses computers that were commercially available at that time. As a result, today the digital control systems are too slow to handle the servo control loops required by present test models. The old circuitry was custom designed, and replacement equipment and parts are no longer available. Problems with the control systems include an excessive number of failures, lack of diagnostic capabilities, excessive time to repair, insufficient data displayed for operators, and operational inflexibility.

As a result, long periods of downtime are being experienced prior to and during wind tunnel operation, seriously reducing the productivity of the facility. It is now estimated that during a typical complex test program, the actual run time is approximately 15 to 17 percent of total occupancy time. This figure is substantially lower than the 25 to 30 percent run time/occupancy time ratio expected in modern tunnels.

IMPACT OF DELAY:

An increasing rate of failures can be expected with continued operation. The resulting lost time will further reduce available test time in the NFAC. As a result, some test programs will have to be deferred indefinitely. Productivity and efficiency will be reduced, resulting in increased backlogs and higher costs for scheduled tests.

PROJECT DESCRIPTION:

This project will replace the controls and displays for the model support systems in both legs of the National Full-Scale Aerodynamic Complex with conventional distributed control systems, including diagnostic capability and operator displays and controls. The distributed control system (DCS) will absorb the position and rate control loop functions of the existing model support control system. The drive variable pitch control system and its related displays will be replaced, and a new smart annunciator package will be provided.

PROJECT COST ESTIMATE:	Unit of Measure	Quantity	Unit Cost	Cost
Construction	---	---	---	$2,100,000
Demolition	LS	---	---	100,000
DCS System and Hardware . . .	LS	---	---	1,000,000
Installation	LS	---	---	1,000,000
Total				$2,100,000

LIST OF RELATED GRAPHICS: Figure 1 - Site Plan Figure 2 - System Drawing

OTHER EQUIPMENT SUMMARY: None

FUTURE CoF FUNDING REQUIRED TO COMPLETE THIS PROJECT: None

AMES RESEARCH CENTER
FISCAL YEAR 1994 ESTIMATES
REHABILITATION OF CONTROL SYSTEMS, NATIONAL FULL-SCALE AERODYNAMICS COMPLEX

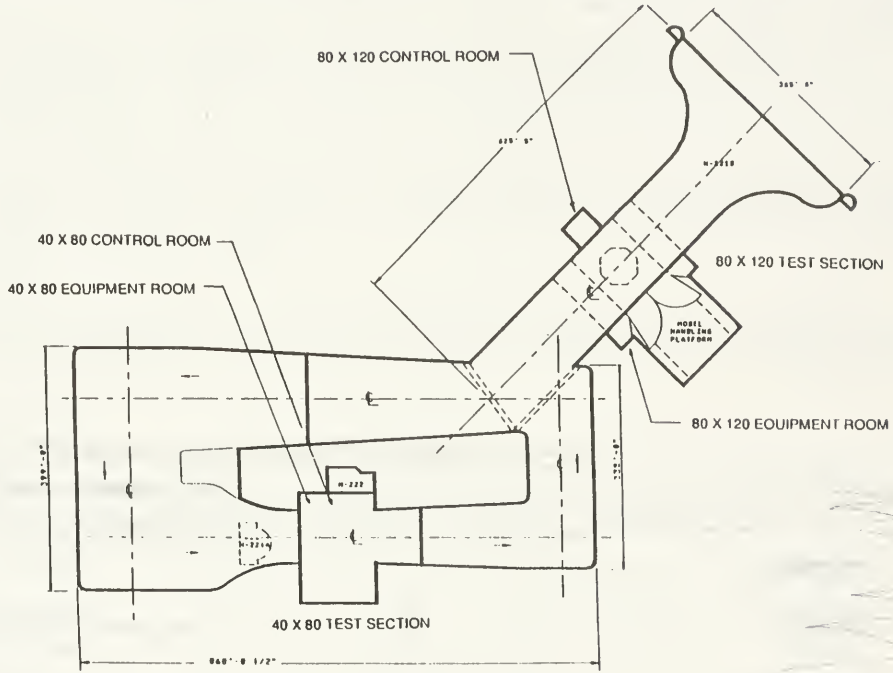


FIGURE 1
SITE PLAN

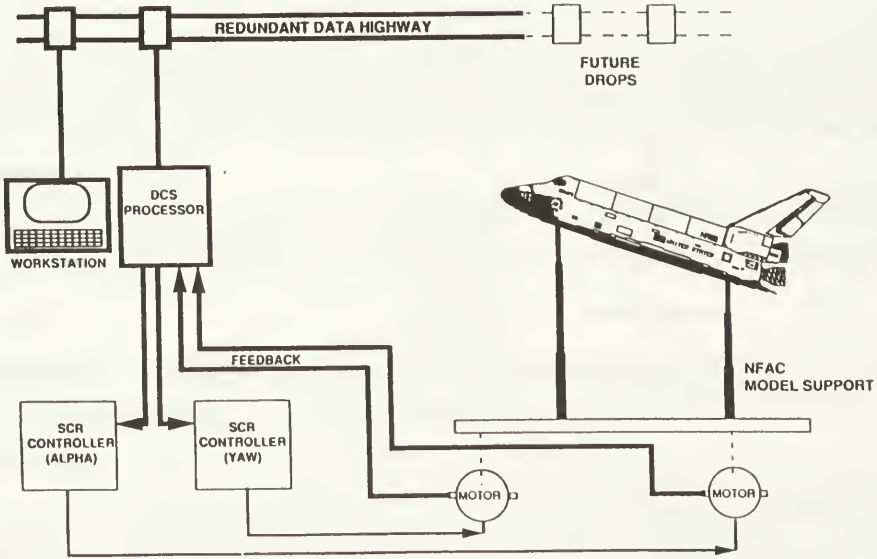


FIGURE 2
SYSTEM DRAWING
(ONE OF TWO SYSTEMS SHOWN)

CF 9B-5

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1994 ESTIMATES

PROJECT TITLE: Upgrade of Outdoor Aerodynamic Research Facility

INSTALLATION: Ames Research Center

FY 1994 CoF Estimate: $3,900,000

LOCATION OF PROJECT: Moffett Field, Santa Clara County, California

COGNIZANT HEADQUARTERS OFFICE: Office of Aeronautics

FY 1993 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF Funding	$239,693	---	$ 239,693
Capitalized Investment	---	$6,433,880	6,433,880
Total	$239,693	$6,433,880	$6,673,573

SUMMARY PURPOSE AND SCOPE:

This project enlarges the Outdoor Aerodynamic Research Facility (OARF) N-249, at Ames Research Center's Moffett Field site to support testing of models and aircraft sized for the 80 x 120 foot leg of the National Full-Scale Aerodynamics Complex (NFAC). The work includes an enlarged model support system; modification of the existing concrete pit and model support framework; development of large-model accessways to the facility; and modification of the storm water drainage system.

PROJECT JUSTIFICATION:

This project is necessary to increase the testing capabilities of the Outdoor Aerodynamic Research Facility in support of the 80 x 120 foot leg of the NFAC. The proposed improvements will enable the OARF to accommodate large models and aircraft scheduled for testing in the 80 x 120 foot leg of the NFAC. The checkout of these models in the OARF will free the 80 x 120 foot leg for other aeronautical testing during model preparation. The OARF has been used for many years to evaluate models and aircraft entering the 40 x 80 foot leg of the NFAC. Hundreds of valuable wind tunnel occupancy hours have been saved by discovering and correcting faulty test hardware prior to using the 40 x 80 tunnel test section. In a similar manner, by increasing the size of the OARF to accommodate models sized for the 80 x 120 foot test section, valuable tunnel time in this leg can also be saved. Currently, large models or aircraft must be checked out in the 80 x 120 wind tunnel itself. This practice increases the time required for each test; limits the number of scheduled test runs; and increases the backlog of other tests because of lowered productivity.

In addition, engine checkouts must also now be performed in the tunnel test section, further reducing time available for actual testing, and increasing hazards to personnel and the tunnel because of the increased time that fuels are in the tunnel; and the risk that an engine will fail while being checked out. Enhancement of the capability of the Outdoor Aerodynamic Research Facility will reduce the backlog, improve utilization of the 80 x 120 foot wind tunnel, and will improve safety by allowing engine checkouts outdoors.

IMPACT OF DELAY:

Model checkout operations and engine checkout will continue to be performed in the test section of the 80 x 120 foot wind tunnel. Continuation of the current approach to model checkout will limit the availability of a unique test facility. Such a delay will result in continuing backlogs in availability of this facility for national aeronautics testing programs.

PROJECT DESCRIPTION:

The project includes a new model support system consisting of two main struts and one tail strut. The proposed load carrying capability will be +/- 150,000 lbs vertical load or lift, +/- 50,000 lbs longitudinal thrust, and +/- 50,000 lbs side force. Tread width and tail length will be adjustable by locally controlled electric motors. The tail strut will be adjustable to provide a +/- 10 degree pitch range. A concrete pit will be constructed to accommodate the increased tread and tail width requirements of the model support struts and recess all model support mechanisms below grade. An access road will be provided from the test section of the 80 x 120 leg of the NFAC to the OARF. Finally, the storm drainage system will be modified to drain the concrete pit and model support system area to an existing oil-water separator.

PROJECT COST ESTIMATE:	Unit of Measure	Quantity	Unit Cost	Cost
Construction:	---	---	---	$3,900,000
Roadways	LS	---	---	812,000
Foundation and Pit	LS	---	---	1,303,000
Model Support	LS	---	---	1,127,000
Model Services	LS	---	---	164,000
Electrical	LS	---	---	494,000
Total				$3,900,000

LIST OF RELATED GRAPHICS: Figure 1 - Site Plan Figure 2 - Schematic

OTHER EQUIPMENT SUMMARY: Existing main struts and ball joints will be provided as Government-furnished equipment.

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT: None

AMES RESEARCH CENTER
FISCAL YEAR 1994 ESTIMATES
UPGRADE OF OUTDOOR AERODYNAMIC RESEARCH FACILITY

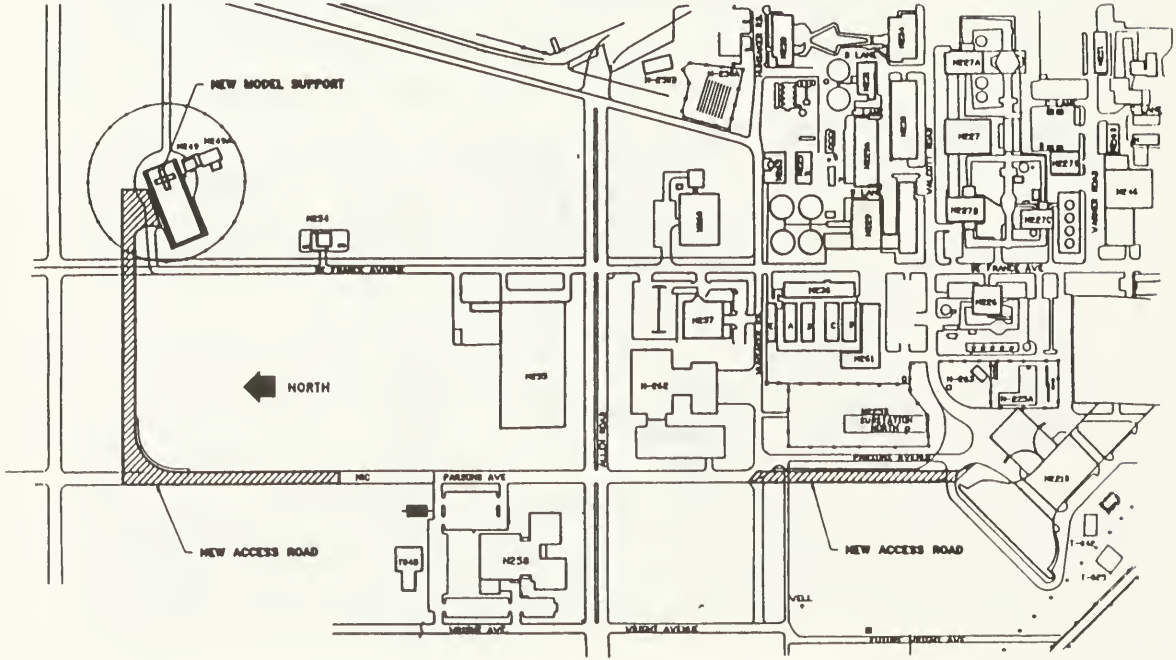


FIGURE 1
SITE PLAN

CF 9B-9

AMES RESEARCH CENTER
FISCAL YEAR 1994 ESTIMATES
UPGRADE OF OUTDOOR AERODYNAMIC RESEARCH FACILITY

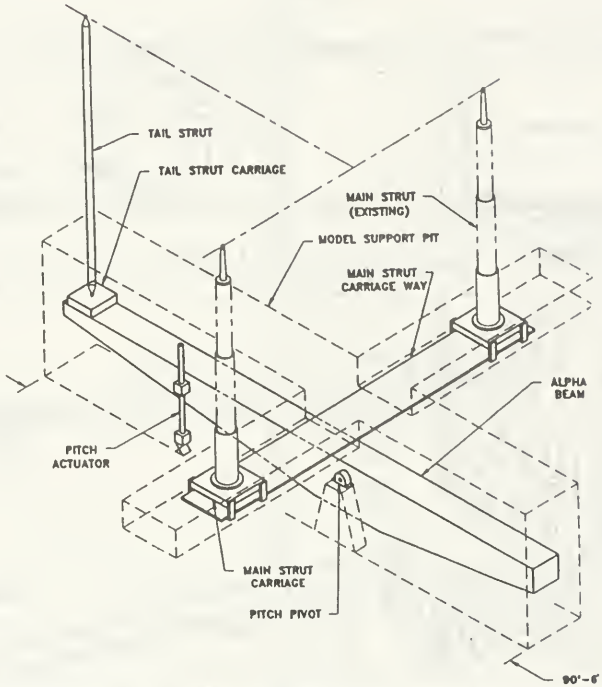


FIGURE 2
SCHEMATIC

PROJECT TITLE: Modernization of the Unitary Plan Wind Tunnel Complex

INSTALLATION: Ames Research Center

FY 1994 CoF Estimate: $25,000,000

LOCATION OF PROJECT: Moffett Field, Santa Clara County, California

COGNIZANT HEADQUARTERS OFFICE: Office of Aeronautics

FY 1993 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF Funding	$4,600,000	$ 8,000,000	$12,600,000
Capitalized Investment	---	50,273,412	50,273,412
Total	$4,600,000	$58,273,412	$62,873,412

SUMMARY PURPOSE AND SCOPE:

This project provides funding for modernization of the Unitary Plan Wind Tunnel Complex to improve productivity, reliability, and the quality of test results. The project will provide new automated tunnel and model support controls; automated controls for tunnel auxiliaries; flow quality improvements in the 11 by 11 foot Transonic Wind Tunnel (11-ft TWT); repair or replacement of aging facility systems; and repair of weld defects in the pressure shell to allow recertification. This increment of work continues construction of the project. This project is included in the Aeronautical Facilities Revitalization Program.

PROJECT JUSTIFICATION:

The Unitary Plan Wind Tunnel (UPWT) is a vital National high-speed tunnel facility consisting of one transonic and two supersonic test sections and supporting auxiliary equipment. This facility is the most heavily used wind tunnel complex in NASA. However, the facility's productivity is limited by the 1950's era control systems and the increasing frequency of equipment breakdowns due to age and heavy use. Modernization is needed now to improve productivity, data quality, and reliability. This complex has been operated on three-shifts-per-day basis since 1956, with minimal improvements to the facility. Tunnel downtime resulting from equipment and control failures has caused major delays to important aircraft projects. Tunnel backlog of testing exceeds two years. Lack of modern data acquisition equipment results in over half of tunnel tests being concluded before all needed data is acquired. Comparable foreign facilities have shown two to three times the productivity achieved in this wind tunnel complex.

The UPWT Complex has contributed to the development of almost every U.S. developed military and civil aircraft flying or nearing service in its speed regime of Mach 0.3 to 3.5, as well as Mercury, Gemini, Apollo, and Space Shuttle spacecraft. For example, programs such as the Air Force F-22, Navy F-18 E/F, Boeing Large Subsonic Aircraft, Douglas MD-90 and MD-12, and NASA High Speed Research (HSRP), are already on the test schedule along with a significant amount of classified testing. The improvements in control and flow quality to be implemented in this project will significantly increase the quality of the simulation.

Repair or replacement of tunnel components that have reached the end of their useful life. Also, the welds in the tunnel shell contain defects typical of 1950's technology and must be repaired and the pressure shell recertified.

IMPACT OF DELAY:

Failure to modernize this facility will increase the delay in acquiring critical test data. The existing (unmodified) facility will continue to fail more frequently, requiring the use of alternate testing resources in Europe and other countries. This in turn, will reduce or delay improvements to U.S. commercial and military aircraft, and will significantly increase the cost of testing. In addition, NASA's leadership role in aeronautical research and development will diminish with incalculable detrimental consequences.

PROJECT DESCRIPTION:

This increment of work will continue construction of facility refurbishments; controls modernization, automation, and replacement; flow quality improvements and pressure vessel shell repair. The total project includes refurbishing and providing automated controls for the tunnel systems, model support systems, make-up air system, and compressor lubrication system; enlarging and modernizing the control rooms; and installing flow quality improvements in the 11-ft TWT. The project also includes refurbishing, repairing, or replacing major components, including the

cooling tower, large electrical switch-gear, and make-up air system; and repairing weld defects in the pressurized portions of the tunnel circuits and make-up air system and recertifying the pressurized systems for safe operation.

PROJECT COST ESTIMATE:	Unit of Measure	Quantity	Unit Cost	Cost
Construction:	---	---	---	$25,000,000
Facility Refurbishments	LS	---	---	6,900,000
Refurbish and Replace Tunnel Control System	LS	---	---	12,400,000
Repair of Pressure Vessels	LS	---	---	4,500,000
Flow Quality Improvements	LS	---	---	1,200,000
Total				$25,000,000

Note: This cost estimate provides for the FY 1994 increment of the project. Prior FY 1993 provided $8.0 million and $30.0 million is estimated for FY 1995. The total cost of the project is estimated to be approximately $63 million.

LIST OF RELATED GRAPHICS: Figure 1 - Site Plan Figure 2 - Perspective

OTHER EQUIPMENT SUMMARY: Data acquisition systems, model check-out equipment, and advanced instrumentation estimated to cost $9.8 million will be located in this facility.

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT: Based on prefinal design, it is estimated that $30 million will be required to complete the project, however, as field investigations progress and design becomes more mature, an updated final increment estimate will be developed.

68-668 O—93——21

AMES RESEARCH CENTER
FISCAL YEAR 1994 ESTIMATES
MODERNIZATION OF THE UNITARY PLAN WIND TUNNEL COMPLEX

SITE PLAN

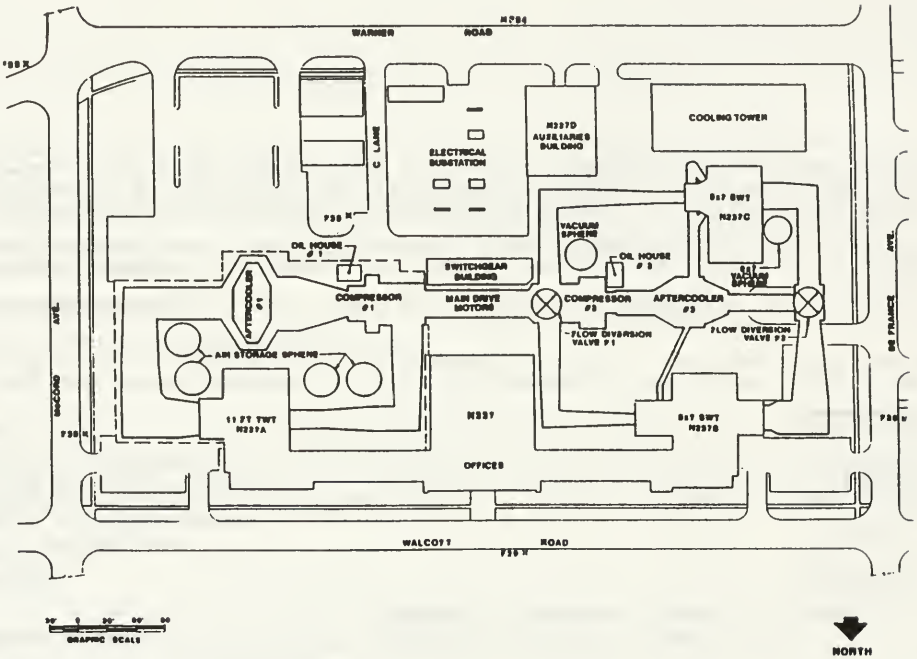


FIGURE 1

CF 9B-14

AMES RESEARCH CENTER
FISCAL YEAR 1994 ESTIMATES
MODERNIZATION OF THE UNITARY PLAN WIND TUNNEL COMPLEX

PERSPECTIVE

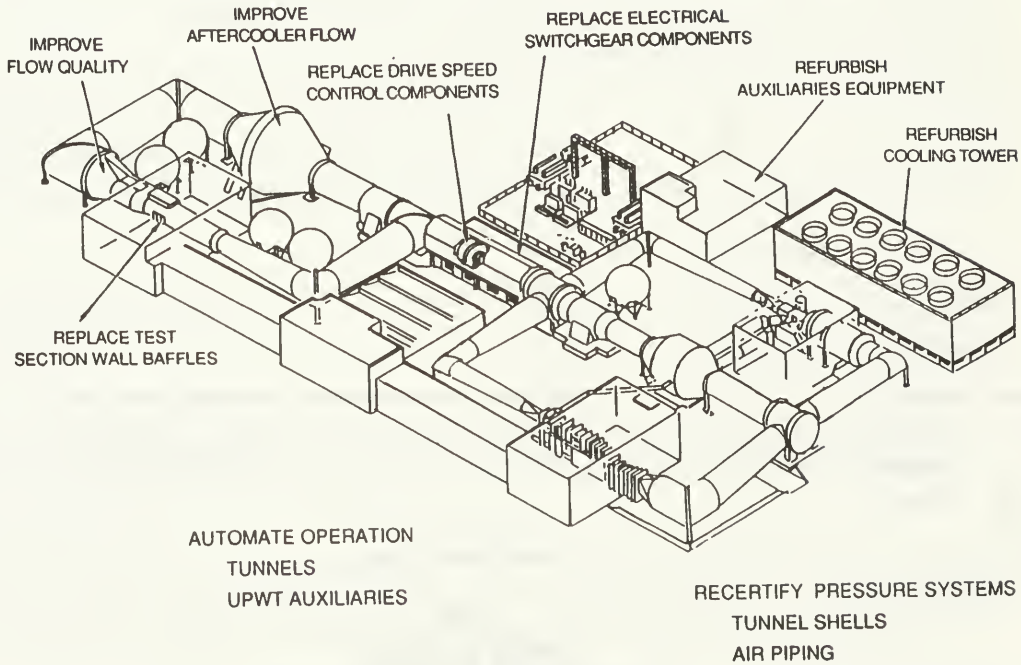


FIGURE 2

CF 9B-15

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
CONSTRUCTION OF FACILITIES
FISCAL YEAR 1994 ESTIMATES

SUMMARY

LANGLEY RESEARCH CENTER

	Amount (Dollars)	Page No.
Mission To Planet Earth:		
Construction of EOSDIS Distributed Active Archive Center (DAAC).....	8,000,000	CF 10-1

PROJECT TITLE: Construction of EOSDIS Distributed Active Archive Center (DAAC)

INSTALLATION: Langley Research Center

FY 1994 CoF ESTIMATE: $8,000,000

LOCATION OF PROJECT: Hampton, Virginia

COGNIZANT HEADQUARTERS OFFICE: Mission to Planet Earth

FY 1993 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF Funding	$760,000	---	$ 760,000
Capitalized Investment	---	$16,454,906	16,454,906
Total	$760,000	$16,454,906	$17,214,906

SUMMARY PURPOSE AND SCOPE:

This project provides for the construction of an approximately 37,000 square foot facility addition to house data processing, data archiving, support space and mechanical/electrical equipment. This facility will house Langley's Distributed Active Archive Center (DAAC) in support of the Earth Observing System (EOS) Program.

PROJECT JUSTIFICATION:

The EOS consists of a scientific research program, a space-based observing system, and a data and information system. It has been determined that the data processing and storage requirements of the project, the Earth Observing System Data Information System (EOSDIS), will be best served with a distributed processing concept with remotely located computer centers at key locations across the country having responsibility for designated experiments and data products.

Langley Research Center (LaRC) will house one of the key Distributed Active Archive Centers with responsibility for routine processing of the EOS data as well as for archiving and full-service distribution of that data. Additional facility space is needed at Langley to support the significant increase of computing and data storage capacity, communications equipment, and support functions essential to meeting EOSDIS program mission and goals.

The EOS Program has put a major emphasis on the data and information system, EOSDIS. EOSDIS is planned to acquire a comprehensive, global, 15-year scientific data set; to maximize the utility of this data set for scientific purposes; and to facilitate its easy access by the research community. Langley's role in this program as a DAAC will be to provide full-service computational support capability for atmospheric and environmental scientists. This facility will contain all the computational resources required to convert raw instrument data into meaningful science products, including the provision of automated archival data storage and retrieval systems, products review in support of science investigators, and media distribution of science products.

IMPACT OF DELAY:

If this facility is not constructed at this time, there will not be adequate space at LaRC to support currently scheduled deliveries of computer and communications equipment in FY 1995, FY 1996 and FY 1997. LaRC will not be able to adequately support NASA's commitment to the Earth Radiation Budget and Upper Atmospheric Research elements of the Earth Observing System and Mission to Planet Earth Program.

PROJECT DESCRIPTION:

This project will provide an approximately 37,000 square foot, two-story addition to the southwest side of the Data Reduction Center Annex Computer Complex, Building 1268B. Floor dimensions are 103' x 180' on the first and second floors. This facility is a fully integrated production facility with major computing equipment and archival capability. The facility will provide approximately 60 percent of the floor space as raised floor for computing equipment with office areas for operations and maintenance support personnel. Other major areas are for power and HVAC systems, user work areas, media distribution, conference facilities, library, and media storage. The facility includes environmental control and fire detection/suppression equipment. Perimeter doors and walls will be designed to provide adequate security. The facility space provides for support offices, data processing, data archival, and site support areas including storage and distribution, equipment/logistical support, conference rooms, library, and mechanical/electrical equipment location. This facility size is based on the dimensions necessary to accommodate project EOSDIS requirements through the year 2015.

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Cost
Construction	---	---	---	$8,000,000
Site Work	LS	---	---	1,940,000
Architectural/Structural	LS	---	---	3,680,000
Mechanical	LS	---	---	1,620,000
Electrical	LS	---	---	760,000
Total				$8,000,000

LIST OF RELATED GRAPHICS: Figure 1 - Location Plan
Figure 2 - Floor Plans

OTHER EQUIPMENT SUMMARY: R&D funding of approximately $64 million will be required to outfit the facility with the necessary communications systems and related equipment.

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT: None

LANGLEY RESEARCH CENTER
FISCAL YEAR 1994 ESTIMATES
CONSTRUCTION OF EOSDIS DISTRIBUTED ACTIVE ARCHIVE CENTER (DAAC)

LOCATION PLAN

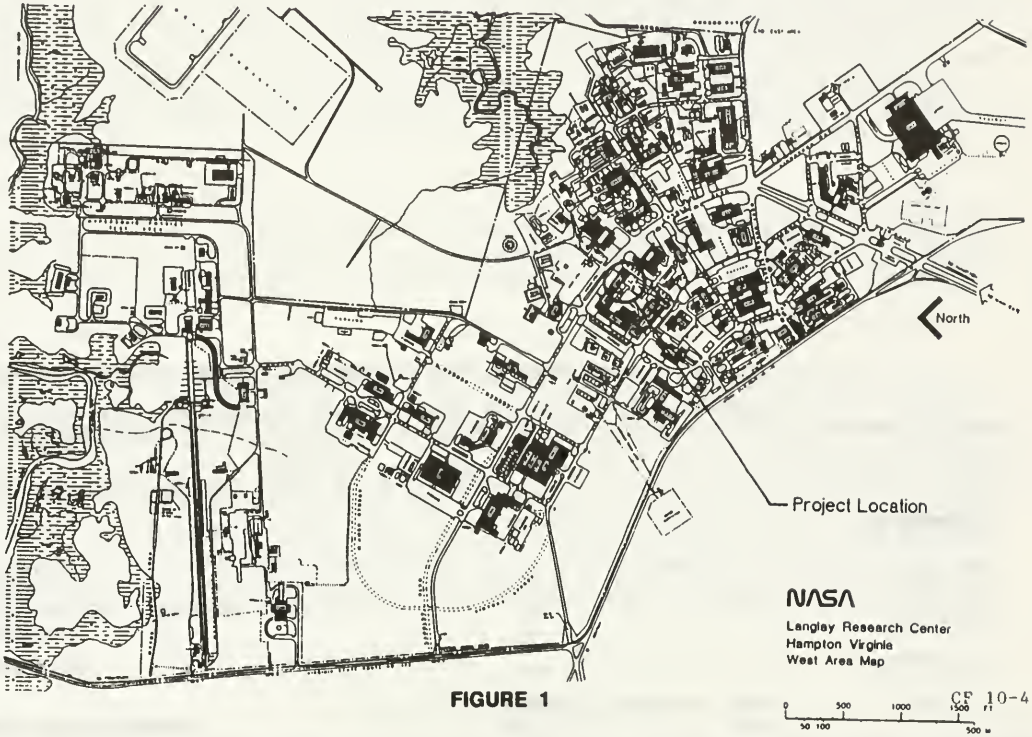


FIGURE 1

CF 10-4

LANGLEY RESEARCH CENTER
FISCAL YEAR 1994 ESTIMATES
CONSTRUCTION OF EOSDIS DISTRIBUTED ACTIVE ARCHIVE CENTER (DAAC)

FLOOR PLANS

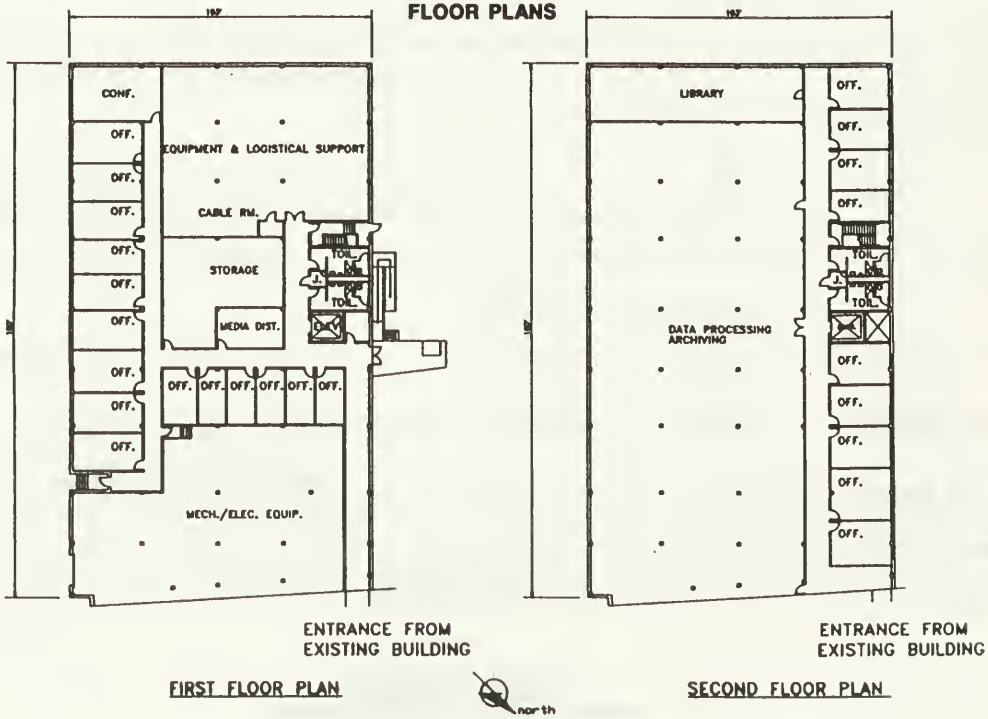


FIGURE 2

CF 10-5

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
CONSTRUCTION OF FACILITIES
FISCAL YEAR 1994 ESTIMATES

SUMMARY

LEWIS RESEARCH CENTER

	Amount (Dollars)	Page No.
Advanced Concepts and Technology:		
Rehabilitation of Rocket Engine Test Facility.....	12,500,000	CF 11-1

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1994 ESTIMATES

PROJECT TITLE: Rehabilitation of Rocket Engine Test Facility

INSTALLATION: Lewis Research Center

FY 1994 CoF Estimate: $12,500,000

LOCATION OF PROJECT: Cleveland, Cuyahoga County, Ohio

COGNIZANT HEADQUARTERS OFFICE: Office of Advanced Concepts and Technology

FY 1993 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project.

	Planning and Design	Construction	Total
Specific CoF Funding	$1,230,000	---	$1,230,000
Capitalized Investment	---	$7,777,000	7,777,000
Total	$1,230,000	$7,777,000	$9,007,000

SUMMARY PURPOSE AND SCOPE:

This project provides for the rehabilitation and modernization of the Rocket Engine Test Facility (RETF) to ensure capability to conduct space propulsion technology programs needed to support Chemical Transfer Propulsion activities, High Thrust Chemical Propulsion Base Research and Technology (R&T), and Earth-to-Orbit Chemical Propulsion. This project will rehabilitate and restore the exhaust muffler/scrubber, water supply, and waste water treatment systems; add capability for advanced liquid fuels; rehabilitate the gas storage systems; rehabilitate facility communication and control systems; rehabilitate the facility site; and construct a new control building.

PROJECT JUSTIFICATION:

The Rocket Engine Test Facility (RETF) is the sole NASA facility for conducting Chemical Propulsion research and technology. This facility's rehabilitated capability is essential for the development of technology for future applications such as the Lunar Transfer Vehicles, Mars Transfer Vehicles, and Advanced Launch Vehicles. This project will ensure the integrity of this facility and will enhance the safety and productivity of its operations.

Lewis Research Center has the lead role in both the Agency's Chemical Transfer Propulsion program and Propulsion Base Research and Technology, in addition to a major role in Earth-to-Orbit Propulsion. These programs require the use of RETF's unique capabilities, which enable work on technology for high area ratio (1000:1) nozzles that will be required for deep space missions. The RETF has the necessary services and capabilities to conduct research in all areas of chemical propulsion using high-performance propellants, such as hydrogen-oxygen, and has operating expertise developed over the past 35 years. Other testing planned for the RETF includes investigations of advanced turbomachinery for hydrogen-oxygen propulsion systems, investigations of potential Lunar/Mars derived fuels, advanced cooling concepts, combustion stability, thrust chamber life, liquid oxygen cooling, and metallized propellants. The NASA Chemical Propulsion Facilities Assessment Team determined that this facility will be required through the year 2020 to conduct these and similar technology programs.

The current 36 year old facility has been conducting rocket tests on a frequent basis. Attendant with the facility age and level of activity is the deterioration of the exhaust muffler/scrubber, which attenuates noise, cools, and cleanses the exhaust from experimental rocket tests. Recent inspections have shown dramatic deterioration, with approximately 60 percent of the capacity unusable and deterioration accelerating rapidly. The cooling water supply system and the waste water treatment systems are also deteriorated and must be repaired to ensure continued test capability. Valves in the supply lines are badly worn and thousands of gallons of water are lost each day through leakage. Some valves are no longer manufactured and repair parts are unavailable, thereby requiring their replacement. This project will significantly improve reliability and productivity through decreased downtime for breakdowns and maintenance.

IMPACT OF DELAY:

Delay of this project will significantly increase the risk of facility shutdown because of system failure. This would seriously impact the critical research activities for Chemical Transfer Propulsion, Propulsion Base Research and Technology, and Earth-to-Orbit Propulsion.

PROJECT DESCRIPTION:

The work includes the rehabilitation of the muffler/scrubber spray system, water supply system, waste water systems, and support structures. Also included is the rehabilitation of the instruments and control systems; installation of a 6,000 psig gaseous hydrogen system, relocation of the existing liquid oxygen system, replacement of existing hydrazine tanks with high pressure, fuel and water run tanks, rehabilitation of gas storage systems (hydrogen, helium, nitrogen), and installation of controls, monitoring and electrical systems; and rehabilitation of the distributed control system, control cabling, conduits, the facility buildings and communication systems, and construction of a new control building.

PROJECT COST ESTIMATE:	Unit of Measure	Quantity	Unit Cost	Cost
Construction	---	---	---	$12,500,000
Rehabilitate Muffler/Scrubber System . .	LS	---	---	3,647,000
Modify High Pressure and Advanced Fuel Systems	LS	---	---	3,312,000
Rehabilitate Facility Systems and Construct Control Building	LS	---	---	5,541,000
Total				$12,500,000

LIST OF RELATED GRAPHICS: Figure 1 - Site Plan

OTHER EQUIPMENT SUMMARY: None

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT: None

LEWIS RESEARCH CENTER
FISCAL YEAR 1994 ESTIMATES
REHABILITATION OF ROCKET ENGINE TEST FACILITY

SITE PLAN

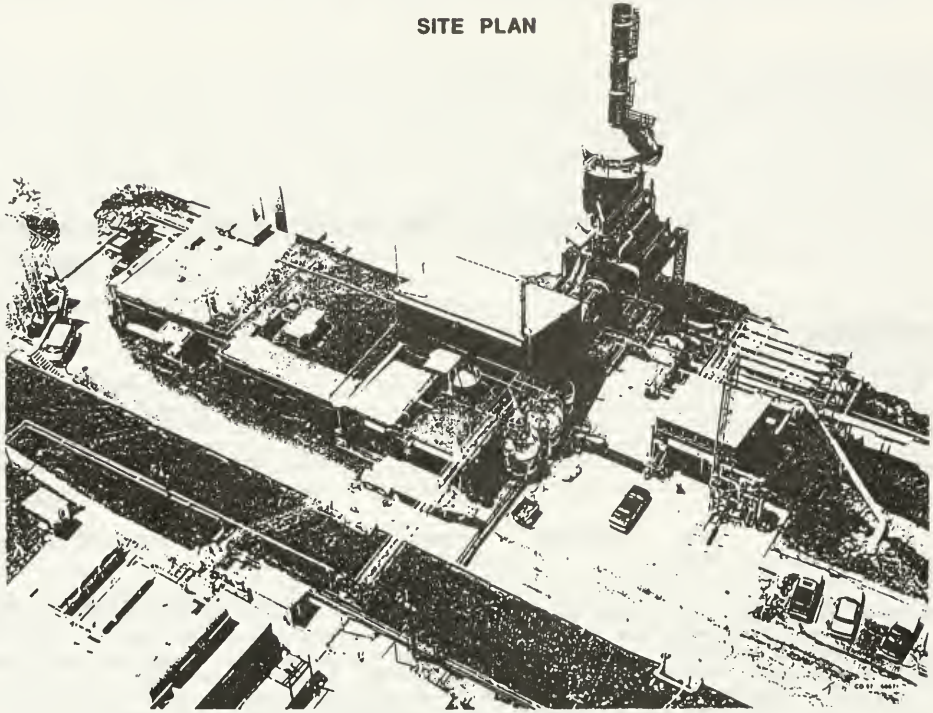


FIGURE 1

CF 11-4

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
CONSTRUCTION OF FACILITIES
FISCAL YEAR 1994 ESTIMATES

SUMMARY

VARIOUS LOCATIONS

	Amount (Dollars)	Page No.
Space Communications:		
Construction of 34-Meter Multifrequency Antenna, Goldstone (JPL).....	17,600,000	CF 12-1

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1994 ESTIMATES

PROJECT TITLE: Construction of 34-Meter Multifrequency Antenna, Goldstone, California

INSTALLATION: Jet Propulsion Laboratory

FY 1994 CoF Estimate: $17,600,000

LOCATION OF PROJECT: Goldstone, California

COGNIZANT HEADQUARTERS OFFICE: Office of Space Communications

FY 1993 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF Funding	$240,000	---	$240,000
Capitalized Investment	---	---	---
Total	$240,000	---	$240,000

SUMMARY PURPOSE AND SCOPE:

This project provides for the construction of a 34-meter high efficiency beam waveguide (BWG) type multifrequency antenna and facilities at Goldstone Deep Space Communications Complex. The new antenna will provide performance improvements for mission support.

PROJECT JUSTIFICATION:

This project initiates the construction of a second subnet of 34-meter high efficiency beam waveguide antennas to the Deep Space Network complexes in Goldstone, California; Madrid, Spain; and Canberra, Australia. The support requirements of the total mission set in the latter 1990s exceed the capability of the existing antenna network. The addition of a second 34-meter multifrequency antenna subnet is vital to ensure Deep Space Network capability in meeting mission support requirements. The new 34-meter multifrequency antennas will provide the additional support capability needed, including X-Band up and downlink.

IMPACT OF DELAY:

This project for Goldstone must begin in FY 1994, so that the new antenna at Goldstone can be completed by August 1996 to provide the full Deep Space Network (DSN) operational configuration needed for the period of intense mission support. Current missions and high priority planned missions included in this period are the Galileo mission to Jupiter, Mars Observer, Cassini, Mars Environmental Survey Pathfinder, Near Earth Asteroid Rendezvous, and Pluto Very Small Spacecraft Flyby. The Deep Space Network also will continue to support the distant Voyager and Pioneer spacecraft in their extended mission phases. Delay of this project would adversely affect the full availability of reliable Deep Space Network support that is needed to meet the intense mission support requirements.

PROJECT DESCRIPTION:

This project includes the design, fabrication, and installation of the antenna structure, panels, gearboxes, bearings, electric drives, encoders, beam waveguide mirrors, subreflector, and subreflector positioner. It also provides for the construction of the foundation and pedestal, as well as all facilities in and around the antenna structure and pedestal, including the antenna apron security fence, heating, ventilation, air conditioning, electrical power distribution and fire detection and suppression systems.

In addition, this project provides for the construction of site facilities including paved access road, trenches, drainage, flood control devices, water main and distribution system.

PROJECT COST ESTIMATE:	Unit of Measure	Quantity	Unit Cost	Cost
Construction	---	---	---	$17,600,000
Antenna Construction	LS	---	---	17,600,000
Total				$17,600,000

LIST OF RELATED GRAPHICS: Figure 1 - Antenna Configuration

OTHER EQUIPMENT SUMMARY: Antenna microwave equipment and electronics and related antenna engineering support required to make this antenna initially operable will be provided with $25 million in Space Flight Control and Data Communications resources over Fiscal Years 1994 through 1996.

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT: None for this specific project; however, similar new 34-meter high efficiency beam waveguide antennas are planned for Madrid, Spain and Canberra, Australia.

VARIOUS LOCATIONS
FISCAL YEAR 1994 ESTIMATES
CONSTRUCTION OF 34-METER MULTIFREQUENCY ANTENNA, GOLDSTONE, CALIFORNIA

ANTENNA CONFIGURATION

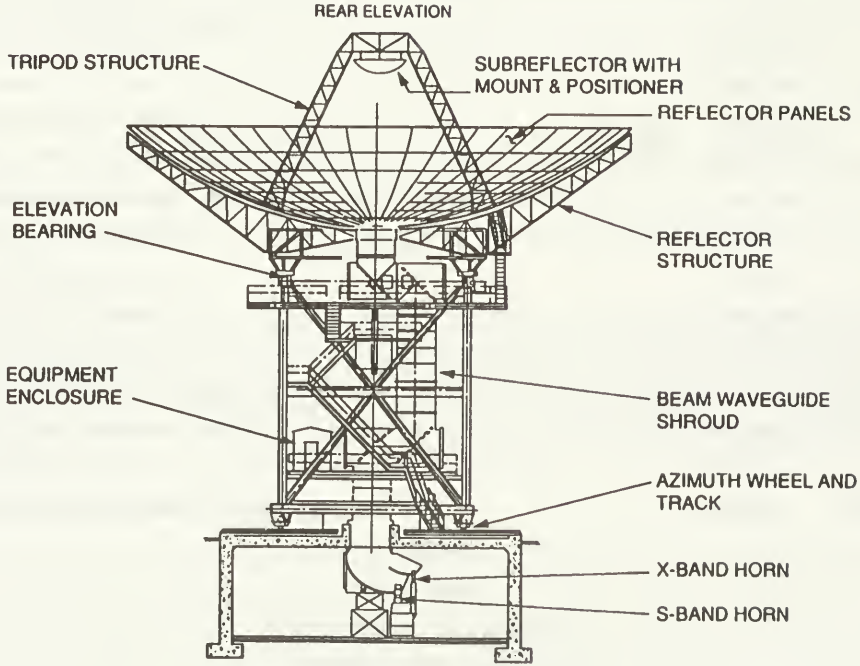


FIGURE 1

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1994 ESTIMATES

SUMMARY

REPAIR

Summary of Project Amounts by Location:	Amount	Page No.
Ames Research Center	$3,270,000	CF 13-3
Dryden Flight Research Facility	1,020,000	CF 13-4
Goddard Space Flight Center	2,700,000	CF 13-4
Jet Propulsion Laboratory	3,200,000	CF 13-6
Johnson Space Center	2,430,000	CF 13-7
Kennedy Space Center	3,690,000	CF 13-8
Langley Research Center	3,800,000	CF 13-9
Lewis Research Center	3,560,000	CF 13-10
Marshall Space Flight Center	3,650,000	CF 13-11
Michoud Assembly Facility	2,600,000	CF 13-13
Stennis Space Center	1,700,000	CF 13-14
Wallops Flight Facility	2,380,000	CF 13-14
Various Locations	1,500,000	CF 13-15
Miscellaneous Projects Not in Excess of $250,000 Each	500,000	CF 13-16
Total	$36,000,000	

PROJECT TITLE: Repair of Facilities, Not in Excess of $1,000,000 Per Project

INSTALLATION: Various Locations

FY 1994 CoF Estimate: $36,000,000

FY 1992: $31,700,000 FY 1993: $31,900,000

COGNIZANT INSTALLATIONS/LOCATIONS OF PROJECT: Various Locations

COGNIZANT HEADQUARTERS OFFICE: Office of Management Systems and Facilities

SUMMARY, PURPOSE AND SCOPE:

These resources will provide for critical repairs to facilities at NASA field installations and Government-owned industrial plants supporting NASA activities. Included in the request are those facility repair needs for FY 1994 that can be identified at the time of the submission of these estimates and are not in excess of $1 million per project. The thrust of this program is to restore facilities and components thereof, including collateral equipment, to a condition substantially equivalent to their originally intended and designed capability. The request includes the substantially equivalent replacement of utility systems and collateral equipment necessitated by incipient or actual breakdown. This work also includes major preventive measures that are normally accomplished on a cyclic schedule.

PROJECT JUSTIFICATION:

NASA is now experiencing "block obsolescence" where a substantial portion of the agency's facilities have been in use for over 25 to 30 years. Repair costs for mechanical and electrical systems in a typical building are almost three times higher after system operations exceed 15-20 years than they are during the initial years. Many electrical and mechanical components reach the end of their serviceable or economic life at the 20 year point and should be replaced in the interest of long-term economy. Continued piecemeal repair of these components is more costly in the long run than replacement at the end of the economic life of the original components. It is estimated that at least 90 percent of NASA's physical plant has been in service for over 25 years.

A major thrust of this repair program is to help preserve the capabilities of the NASA physical plant, which has a capital investment of $4.9 billion and a current replacement value of more than $15 billion. This work must be addressed and progressively accomplished. Otherwise, risks are increased and future repair costs will be significantly greater. More importantly, there will be increased breakdowns, interruption of critical operations, and costly unscheduled repairs incurred.

This program includes only facility repair work having an estimated cost not in excess of $1 million per project. The work is of such a nature and magnitude that it cannot be accomplished by routine day-to-day facility maintenance and repair activities. Repair projects estimated to cost more than $1 million are included as separate discrete projects in the budget request.

PROJECT DESCRIPTION:

Proposed repair projects for FY 1994 totaling $36 million are described under "PROJECT COST ESTIMATE." This repair program has been distilled from requests in excess of $62 million, and thus represents a modest request in relation to the continuing backlog of this type of work. The projects that comprise this request are of the highest priority based on relative urgency and expected return on investment. Deferral of this mission-essential work would adversely impact the availability of critical facilities and program schedules. Projects estimated to cost not in excess of $250,000 have not been individually described or identified by Center. The total request for this category is $500,000.

During the course of the year, it is recognized that some rearrangement of priorities may be necessary. This may force a change in some of the items to be accomplished. Any such changes, however, will be accomplished within total available repair resources. The following broad categories of work are described further in the "PROJECT COST ESTIMATE":

a.	Utility Systems	$8,950,000
b.	General Purpose Buildings	6,850,000
c.	Technical Buildings/Structures	8,950,000
d.	Pavements and Drainage	2,770,000
e.	Building Exteriors and Roofs	8,480,000

PROJECT COST ESTIMATE:

A. Ames Research Center (ARC) $3,270,000

1. Repair Steam Vacuum System Boiler and Feedwater System, N-234A 600,000

Pressurized components of the boiler feed-water system of the Arc Jet steam vacuum system in Building 234A will be repaired and replaced in this project. This system supports operation of all Arc Jet facilities. A rupture in the system can result in a high-pressure steam release, which can have catastrophic results. The boiler is approximately 30 years old and requires replacement to assure continued safe operation.

2. Repair of Pressure Systems 500,000

This project provides for repair and replacement of underground high-pressure air lines linking compressor and storage facilities with research facilities. It includes pipe replacement, corrosion control, and reconnection of instrumentation and control systems. The high-pressure lines have been in use since the 1960s. Corrosion-caused leaks and weld defects have been discovered. Significant structural damage has already occurred in one building where an air leak caused upheaval of the floor. The system requires repair to reduce the risk of catastrophic failure.

3. Repair Roof, N-243 500,000

The Flight Guidance and Simulation Laboratory roof will be replaced with a new roof sloped to allow water runoff. Included are insulation, membranes, flashings, and drains. The roof is currently leaking and maintenance efforts have proven futile in providing a permanent solution. Interior ceiling tiles and walls have been damaged by 13 leaks over the past two years. The roof is deteriorated and is at the end of its life.

4. Repair High Reynolds Channel II Pressure Control System, N-231 420,000

This project will replace the High Reynolds Channel (HRC) II pressure control valve to control the flow of 3,000 psi air to the HRC facility. The work will include piping modifications and replacement of valve hydraulics and controls. The current valve configuration causes undesirable and disruptive pressure fluctuations at certain operating pressures, limiting research capabilities.

5. Repair Heating, Ventilating, and Air Conditioning System,
Area B, N-241 400,000

This project will include replacement of the chiller, chilled water pump, and air handling unit supporting Area B of the Administrative Management Facility. The existing system is over 22 years old and is beyond its useful life. Chillers and the air handler are corroded

and operating beyond design capacity. Comprehensive rebalancing of the system is needed due to additions and modifications for computer rooms and offices.

6. Repair Heating, Ventilating, and Air Conditioning System, N-213 850,000

This project provides for replacement of two boilers, a chiller, and other air conditioning equipment in the Research Support Building. The HVAC system in the east half of the building is over 28 years old, and the system in the west half of the building is over 35 years old. Both have repeatedly broken down during the last few years, and can no longer be repaired economically because replacement parts must be custom fabricated.

B. Dryden Flight Research Facility (DFRF) $1,020,000

1. Repair Building 4820 450,000

This project provides for repair and replacement of various components of the Flight Loads Research Facility. The work includes the roof; the heating, ventilating, and air conditioning (HVAC) system; and the compressed air system and ceiling fans. The building is dilapidated. The roof leaks, and the HVAC system shuts down intermittently, causing overheating of computers. The compressed air system is 25 years old, energy inefficient, and not adequately sized.

2. Repair Building 4826 570,000

This project provides for repair of the roof; heating, ventilating, and air conditioning (HVAC) system; and floor of the Aircraft Maintenance Dock. The roof is over 20 years old and can no longer be maintained. The HVAC is old and unrepairable because parts must be custom fabricated. The floor is cracked and uneven due to settlement of the subgrade. Repairs must be accomplished to assure a safe work environment.

C. Goddard Space Flight Center (GSFC) $2,700,000

1. Repair Roofs, Various Buildings 550,000

This project provides for removal of existing roof assemblies and replacement with a modified bitumen single ply roof system. Roof replacement will take place for portions of Buildings 8, 20, and 12, comprising an approximate total area of 46,200 square feet. Flashing, coping, and parapets will be repaired or replaced as necessary. The building roofs identified are at significant risk of failure. The roofs are maintenance problems, and the risk to people, space, and equipment requires that they be repaired as soon as possible.

2. Repair Heating, Ventilating, and Air Conditioning (HVAC) Induction Systems, Various Buildings 700,000

This project provides for the replacement of approximately 1,790 control valves on HVAC induction units in Buildings 3, 7, 14, 16, 21, 22, 23, 26, and 99. The project includes replacement of deteriorated control valves, branch isolation valves, and modifications to associated piping connections. The valves, couplings, and associated piping for induction units in these buildings are badly deteriorated. This condition results in leakage, erratic temperature/humidity control, and high maintenance costs.

3. Repair Building Exteriors and Foundations, Buildings 3 and 13/14 . . . 400,000

This project proposes the repair of various building elements in the Building 3/13/14 complex. This includes the repair/installation of footing drains, repair of cracks in foundation walls, waterproofing of the foundations, removal and replacement of sidewalks, regrading the landscaped areas to direct water away from the building complex, associated excavation, resealing of the curtain wall system, and replacement of the curtain wall parapet cap and sealant. The Building 3/13/14 complex shows numerous signs of water damage. Many of the rooms affected are transformer rooms and mechanical rooms on the basement and sub-basement levels. The cause of this leakage has been determined to be ineffective or non-existent waterproofing, damaged drain systems, improper grading, dry and cracked sealants, and cracks in the building foundation. The proposed work will restore facility integrity and minimize potential loss of property caused by water damage.

4. Repair Paved Surfaces 600,000

This project proposes the repair and upgrade of Explorer Road to four lanes from Building 2 to the Building 17 gate; repairs to exterior sites adjoining Buildings 12, 13, 14, and 28, including sidewalks, parking surface overlays, sealing cracks in the parking surfaces, painting parking stalls, seal coating, and repair of curbs, gutters, and drainage basins; and regrading of lawn areas to prevent ponding of rain water. This project is required for the increased usage of Explorer Road projected as a result of Eastern Campus development. This work is also required to eliminate current excessive maintenance and to restore good operating conditions. Numerous potholes, depressions, and alligatoring have developed, resulting in accelerated deterioration and unsafe conditions. Sidewalks are cracked and uplifted, causing tripping hazards.

5. Repair Interior Lighting System, Various Buildings 450,000

This project provides for replacing the existing high bay lighting systems with a state-of-the-art high-intensity discharge lighting system in Buildings 7, 11, 15, 16W and 22. The existing high bay lighting systems in these buildings are nearly 30 years old and require complete replacement. Operation and maintenance costs are excessive due to age. The new high-intensity discharge lighting will provide a more reliable, efficient and maintainable system.

D. Jet Propulsion Laboratory (JPL) $3,200,000

1. Repair Curtain Wall System, Space Flight Support Building (264) 900,000

This project provides for the repair of approximately 45,000 square feet of existing curtain wall on all four sides of this seven-story building. Repair will include replacement of the corroded horizontal and vertical aluminum mullions, all glazing and sealing gaskets, and application of building sealants. The building experiences severe leakage on all sides. Mullions are corroded and glass plates have blown out creating hazard potential to personnel. Water leakage soaks carpeting, electrical cords, and electrical equipment creating hazardous conditions and increasing maintenance costs.

2. Replace Ceiling and Lighting Systems, Instrumentation Systems Laboratory (168) 900,000

This project provides for the replacement of the ceiling system and light fixtures in laboratories and corridors. The heating, ventilating and air conditioning system (HVAC) will be modified to eliminate corridors as a return plenum. Air registers above doors will be eliminated and replaced with new air diffusers and return registers in the ceilings. Smoke-tight gasket seals will be installed on corridor doors. Spot removal and encapsulation of asbestos fire proofing will be provided on selected areas of the building's structure. These repairs are required to bring this building into compliance with fire, seismic and other life safety codes.

3. Repair Paving on Mesa, Gyro and Magnetometer Roads 500,000

This project provides for the repair of approximately 125,000 square feet of Mesa Road and approximately 600 linear feet of Gyro and Magnetrometer Roads leading up to Buildings 251 and 253 and the parking areas adjacent to the buildings. The deteriorated asphaltic concrete will be removed and replaced with approximately three inches of new asphaltic concrete on six inches of crushed aggregate base course. Resetting of existing manholes, valve boxes, and catch basins and construction of curbs and gutters will be accomplished to accommodate site requirements. This pavement, which is over twenty years old, is severely deteriorated. It is cracked, alligatored and ravelled with bumps, depressions and potholes.

4. Replace Paving, West Parking Lot 900,000

This project provides for the removal and replacement of approximately 400,000 square feet of asphalt paving on the West Parking Lot. The paving will be removed, ground and reused as a base for the new approximate 2 1/2 inch thick asphalt paving. Concrete surface drainage system will be provided to accommodate run-off to the existing storm water control system. The parking layout will be re-designed and striped to provide the maximum number of parking stalls and designated handicapped parking spaces. This is the original pavement from

1962, and the surface has settled in spots, leaving an uneven surface with numerous cracks that allow water to penetrate causing additional deterioration.

E. Johnson Space Center (JSC) $2,430,000

1. Repair Standby-Power Diesel Engines, Building 48 900,000

This project provides for the replacement of three diesel engines with an uninterruptible power supply system in the Emergency Power Building, Building 48. The generators are approximately 30 years old and have exceeded their useful, reliable life. These critical systems provide emergency power to the Mission Control Center.

2. Repair Electrical Power Distribution Equipment, Building 24 600,000

This project provides for the replacement of major electrical equipment in the Central Heating and Cooling Plant, Building 24. The existing transformer will be replaced and connected to a new Motor Control Center (MCC) by a new 3,000 ampere bus duct and main tie breakers. An existing 400 ampere MCC will also be replaced. The existing MCC is over 30 years old and has exceeded its useful life. Replacing the transformer and MCC will increase the electrical distribution system reliability.

3. Repair 400 Area Altitude Simulation System, White Sands Test Facility (WSTF) 510,000

This project provides for the overhaul and refurbishment of the diesel engines, associated power transmission units, and water and alcohol pumps that supply fluids to the chemical steam generation modules for the 400 Area altitude simulation system. The engines and pumps are over 25 years old and have exceeded their useful life. These systems are a vital part of the altitude simulation system used for testing propulsion engines and systems in NASA's space flight programs.

4. Repair Base Wide Roads and Parking Areas, White Sands Test Facility (WSTF) 420,000

This project provides for repair of deteriorated roads and parking lots at the WSTF. Work includes repairing cracks, broken edges, utility trench cuts, rebuilding road shoulders, applying a bituminous surface seal, paving additional areas, and restriping on-site roads and parking areas. The edges of many roadways and corners are broken and in need of repair to prevent water migration beneath the pavement. If these pavements are allowed to deteriorate further, complete replacement will be required at a much higher cost.

F. Kennedy Space Center (KSC) $3,690,000

1. Repair Operation and Checkout (O&C) Building Roof, Area J 370,000

This project will replace approximately 36,500 square feet of roof system on the O&C Building. Work will include replacing insulation and flashing. The condition of this part of the roof has deteriorated such that normal maintenance is no longer adequate, and water entering the building could cause damage to flight hardware and ground support equipment. This facility is the primary payload assembly and checkout facility.

2. Repair Aboveground Hot Water Piping, Industrial Area 650,000

This project will replace approximately 2,000 feet of high temperature hot water piping and approximately 38,000 feet of aluminum jacket and insulation. Mower guards will be installed to prevent damage to the piping and insulation. Piping and insulation need to be replaced because of mechanical damage and weathering caused by environmental conditions. Additional protection is required to prevent further damage to the piping and insulation system.

3. Repair Shuttle Landing Substations 620,000

This project replaces the 70,000 volt single-phase regulators in the Shuttle Landing substation. The substation enclosures are badly corroded and are susceptible to water intrusion. Additionally, these substations, which provide electrical power to the Shuttle Landing Facility (SLF) Approach lighting systems, are obsolete. Replacement/spare parts for these 20-year-old systems are difficult and expensive to obtain. A safe reliable visual guidance system is vital to SLF and Shuttle night operations. The existing obsolete system needs to be replaced with an up-to-date, reliable system to assure safe SLF and Shuttle night operations.

4. Repair Building 836 Firex System, Vandenberg 850,000

This project will replace the existing wet pipe sprinkler fire protection system at NASA Vandenberg Building 836 with a dry pipe pre-action sprinkler system. The sprinkler system is approximately 30 years old, which increases the risk of serious damage to spacecraft and flight hardware due to mechanical failure of the wet pipe system. The existing systems are pressurized to 140 psi, and significant leaks have occurred in the past few years. Recent failures have required riser valve and pipe replacement because of corrosion.

5. Repair Kennedy Parkway North 600,000

This project repairs Kennedy Parkway northbound from NASA Causeway to Saturn Causeway, approximately 4.5 miles of two-lane road. Approximately 2,000 tons of asphalt concrete will be required as a leveling course due to settling of the road bed. A 1-inch

asphaltic concrete overlay will be applied to approximately 65,000 square yards of pavement along with approximately 72,000 feet of pavement striping. This road is a primary traffic route for KSC personnel and is used for transporting Shuttle payloads. Cracking has caused moisture to enter the road base causing deterioration of the base and thus undermining the wearing course.

6. Repair Hangar N Roof, Cape Canaveral Air Force Station 600,000

This project replaces approximately 33,800 square feet of existing built-up roofing at Hangar N with a new 4-ply built-up roofing system, including insulation, graveltop, gutters and flashing. Accrued deterioration due to weathering (ponding water, ultra-violet rays, expansion and contraction of materials) has caused breaks, splits, and ridging of the roof system and has allowed water intrusion. Normal maintenance of this roof system is no longer adequate.

G. Langley Research Center (LaRC) $3,800,000

1. Repairs to High Pressure System, Various Facilities 600,000

This project provides for repairs to the high pressure systems at various facilities at Langley Research Center. The work to be done under this project includes the replacement of defective piping, valves, and fittings; radiographic inspection of welds; and repair of defective welds. The systems to be repaired include piping systems and pressure vessels at the West Area Steam Distribution System, the Gas Dynamics Laboratory (1247), the Radiation Re-entry Laboratory (1275), and the Structures and Materials Laboratory (1148). These systems are being analyzed and spot inspected under LaRC's ongoing Recertification Program. Completion of this project is essential to ensure the safe and efficient operation of the research facilities.

2. Repairs to Chilled Water System (1268/1268A) 550,000

This project provides for the replacement of an existing 22-year-old centrifugal chiller (No. 4) and installation of a new cooling tower serving the Central Scientific Computing Facility at LaRC. The work includes the removal of an existing chiller, modifications to foundations, piping, and electrical service for the installation of the new chiller. The work will also include all pumps, piping that interconnects with the existing cooling water system, controls, and electrical components associated with the installation of the new cooling tower. Implementation of this project is necessary to ensure the reliability of the chilled water system which supports LaRC's computing facility.

3. Replace Roof, Building 1250 400,000

This project provides for the replacement of approximately 25,100 square feet of existing built-up roofing above the office area and the high bay area of the Environmental and Space Sciences Laboratory, Building 1250. The new roof will consist of rigid roof insulation

covered by a 4-ply built-up roof system, complete with necessary roof drains and associated plumbing, flashing, facia, pitch pockets, cant strips, gravel stops and new expansion joints/seals where necessary. Also the old abandoned exhaust housings will be removed. Because normal maintenance is no longer effective, replacement of this roof is required to ensure the integrity of the facility and to prevent damage to equipment.

4. Repairs to Kramer Drive System (1241) 900,000

The project provides for rewinding of the "A1", "A2", and "A3" machines in the Kramer speed control drive system located in facility 1241. It will also replace the DC loop power cables with new cables. The failure of this 45-year-old Kramer Drive speed control system would result in the shutdown of the 16-Foot Transonic Tunnel and the National Transonic Facility.

5. Replacement of 100-Foot Sphere Steam Ejector (1247) 570,000

This project provides for the replacement of the existing 30-year-old steam ejector system with a new 3- or 4-stage system. The connection point to the vacuum sphere system will be relocated to provide additional flexibility. A new, more efficient system would eliminate excessive maintenance costs, reduce steam consumption, increase productivity, and greatly diminish the noise and the vapor cloud created by the existing system configuration.

6. Replace 10,000 CFM Compressor for 8-Foot Transonic Pressure Tunnel (640) 780,000

This project provides for the replacement of the 40-year-old 10,000 CFM compressor serving the 8-Foot Transonic Pressure Tunnel located in Building 640 of Langley Research Center's East Area. The project will include replacement of the compressor and its ancillary equipment and modifications to the existing compressor foundations and subsystems. The compressor has deteriorated over the years and it is extremely difficult to obtain replacement parts to keep it in working condition. Failure of the compressor would halt operation of the 8-Foot Transonic Pressure Tunnel.

H. Lewis Research Center (LeRC) $3,560,000

1. Repair Central Water Distribution System 900,000

This project provides for the repair of the central water distribution system. The work includes the replacement of the incoming 24" diameter domestic water supply located along Hangar Access Road. It also includes connecting the 8" to 23" diameter existing piping that distributes water to the Center. Mineral deposits on the inside of the main supply line have contributed to a general reduction in water flow throughout the Center. This project is an important part of a multi-year program to increase water pressure and improve water quality for the various buildings served.

2. Repair 34.5 KV Equipment, Building (142) 900,000

This projects provides necessary repairs to the 34.5 kV electric power distribution system at LeRC to ensure safe and reliable power to critical institutional loads. The work includes removal and replacement of cable in poor condition, installation of a new bus to provide a second source of power to Substation C, and rehabing transformers and related auxiliary equipment. This project will avoid shutdown during maintenance periods, eliminate single point failures, and improve system reliability and safety.

3. Repair Steam Trenches, Various Locations 900,000

This project provides for the repair and replacement of piping and valves at various locations in the steam distribution system. The locations will also require road excavation, trench cover replacement, drainage and manhole repairs, piping and valve reinsulation, trench water level sensor installation, and roadway resurfacing. Existing conditions include collapsed sections of trench and roadway; severe concrete deterioration due to road salts and freeze-thaw cycling; advanced corrosion of condensate piping and pipe supports due to the trench environment; and poor condition of steam line insulation, valves, and expansion joints. This project will provide safe, reliable steam service to critical research buildings and administrative functions.

4. Repair Sanitary Sewer System, Plum Brook Station 860,000

This project will repair or replace segments of the sanitary sewer system at Plum Brook, which have high inflow/infiltration rates that result in excessive flow into treatment plant. Portions of the system needing repair are lower Taylor Road branch; upper Maintenance Road branch; Garage branch, which includes hazardous waste cleanup; K-site branch; upper Taylor Road branch; Administration branch; Chemical Laboratory branch; and Space Power Facility branch. This project phase will repair the system and result in reduced flows into the regional sewer district and reduce treatment costs.

I. Marshall Space Flight Center (MSFC) $3,650,000

1. Replace High Pressure Air Storage Capacity 850,000

This project provides for the purchase and installation of one air carbon steel storage vessel in the Test Area to restore capacity lost as a result of the down rating of existing air and hydrogen vessels. In order to satisfy the current demand for high-pressure air, the Center is operating its air stations for two 8-hour shifts per day, 7 days per week. As existing vessels deteriorate due to age, they are downrated or taken out of service. It is no longer economical nor practical to make up for this loss of capacity by making operational changes such as working additional shifts.

2. Repairs to High Pressure Piping System 600,000

This project provides for the replacement of approximately 7,000 linear feet of high pressure gas piping and associated components throughout the Center. This piping is part of the high pressure distribution system for hydrogen, helium, nitrogen, and high-purity air. This system provides critical support to major test programs; it is very old and deteriorated, and continued piecemeal repairs are costly and disruptive to testing activities.

3. Repair Roof of Computer Facility (4663) 650,000

This project provides for the replacement of the roof on Building 4663. The work includes replacement of approximately 75,000 square feet of roofing membranes, installation of a lightweight R-30 roof insulation system, selective replacement of flashing, and the removal of unnecessary expansion joints and vents. The existing roof has already exceeded its life expectancy and is very deteriorated. Repair of this roof will preserve the integrity of the facility, reduce maintenance costs, and provide energy cost savings.

4. Repair Exterior of Engineering and Development Laboratory (4708) . . . 850,000

This project provides for exterior repairs to Building 4708. The work includes the replacement of exterior asbestos siding with new insulated metal panels; and the repair, replacement, or installation (as required) of windows, gutters, downspouts, entrance canopies, curbs, and sidewalks. Building 4708 is a 292,000 square foot high bay facility, over 30 years old and very deteriorated. The new insulated siding and windows will provide an energy-efficient and low-maintenance building envelope.

5. Repair Multipurpose High-Bay Facility (4655) 700,000

This project provides for repairs to Building 4655. The work includes the replacement of windows and exterior siding; replacement or installation, as required, of heating, ventilation, and air conditioning systems; and restoration of the electrical distribution system. Also included is the restoration and/or reconfiguration of interior surfaces, restrooms, interior lighting, and emergency exit signs. Building 4655 is an 11,200 square foot high-bay facility. It is over 25 years old and requires extensive maintenance. The new insulated siding and windows will provide an energy-efficient and low-maintenance building envelope. Restoration of this facility will bring it into compliance with applicable codes and significantly improve its functionality.

J. Michoud Assembly Facility (MAF) $2,600,000

1. Repair Building 102, Zone 8 600,000

This project provides for the repair of the interior systems of Zone 8 of the Engineering Building (above the cafeteria). The work includes replacement of the supply/return duct work, electrical distribution/cabling system, existing acoustical ceiling/lighting system, and modification of the overhead sprinkler and fire alarm systems. This building is over 40 years old and has never received a major interior building restoration. These repairs are required to provide an adequate workplace environment.

2. Repair Sewer Lift Stations 300,000

This project provides for the repair of sewer lift stations that are part of the Center's sanitary sewer system. The work includes replacement of components such as pumps/motors, electrical systems, piping/valves, flotation devices, and surge tanks. Also included is the repair of the walls in the wet wells of the lift stations. These stations are over 45 years old and have never been overhauled. The pumps, valves, and pipes are leaking; the motors are continuously failing; the controls do not function; and the electrical systems are obsolete.

3. Repairs to Acceptance and Preparation Building 900,000

This project provides for the repair of the heating, ventilation, and air conditioning (HVAC) and power systems in Building 420. The work includes replacement of air handling units with associated piping, valves, and controls; replacement of reheat coils in ductwork and control valves; and replacement of 480 v power distribution panels. Building 420 is a 27 year old, 110,000 square foot facility with four high bay cells. The HVAC system has exceeded its design service life. The power system is obsolete and spare parts are no longer manufactured for it. The proposed repairs will improve the reliability and maintainability of these systems, and reduce operations and maintenance cost.

4. Repairs to Vehicle Component Supply Building 800,000

This project provides for the repair of the heating, ventilation, and air conditioning (HVAC) system in Building 220. The work includes replacement of selected air handling units with associated piping, valves, and controls; and replacement of the chilled water and steam piping, also with associated valves and controls, between Buildings 207 and 220. Building 220 is a 26 year old, 201,000 square foot facility. The equipment and piping to be replaced have exceeded their design service life and are very deteriorated. The proposed repairs will improve system reliability and maintainability, and reduce operations and maintenance cost.

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K. Stennis Space Center (SSC) $1,700,000

1. Repair Main Substation Switchgear and Enclosures 800,000

This project provides for the replacement of the existing 13.8 kV main substation switchgear and the associated relaying and metering systems. Equipment to be replaced includes air circuit breakers, lightning arresters, relaying for overcurrent and ground fault detection and interruption, and metering. New solid state relaying, metering and utility control system equipment for the new bus tie breakers will be provided. New exterior vacuum circuit breakers with isolation and bypass switches will replace the existing air circuit breakers. The existing substation equipment is more than 30 years old and has exceeded its useful life. Three major component failures along with numerous failures have occurred in recent years.

2. Repair Shuttle Parkway 900,000

This project provides for the resurfacing of the east and west bound lanes of Shuttle Parkway (Highway 607) from the Mississippi State highway maintenance limits to the north gate (approximately 28,800 square yards) and from the Mississippi State highway maintenance limits to the south gate (approximately 64,800 square yards). Work includes repairs to cracks in existing roads, base repairs, the application of a tack coat followed by overlaying with one and one-half inches of bituminous surface. Road shoulders will be dressed and seeded. Cyclic repair of this parkway is needed in order to preserve the road system from excessive surface deterioration, prevent further breakdown of pavement structure, and to maintain a high level of safety.

L. Wallops Flight Facility (WFF) $2,380,000

1. Repair Seawall 900,000

This project provides for the repair of the Wallops Island seawall to complete protection of the South Launch Area and extend the protection north of Launch Area Five. The construction will be seaward of the existing seawall and include all necessary toe protection. This work is necessary to prevent or minimize storm damage, which is becoming increasingly common due to beach erosion and deterioration of the existing protection system.

2. Repair Storm Drainage System 550,000

This project provides for the repair of approximately 45,000 linear feet of 8-inch to 54-inch storm drainage system piping and manholes on the mainbase and airfield areas. The work will include all related work such as street repair due to storm drainage damage to the subbase materials. Surface drainage problems will be corrected through the installation of new underground drains and the installation of swales and culverts. This project is required to repair deteriorated storm drains and to correct drainage deficiencies due to facility changes over the past 40 years. The work should be accomplished at this time to prevent additional

system deterioration, which could lead to the undermining of roads, airfield pavements, and structures.

3. Repair Exterior, Building F-10/10B 350,000

This project provides for the repair of building F-10 and adjacent laboratory building F-10B. The work includes the covering of the brick exposed south side and southwest corner of building F-10 and the exterior of building F-10B with preformed metal panels; the addition of a new insulated roof system, thermal windows and doors, fire protection, and HVAC system in F-10B; enclosure of the exterior stairway in F-10 with steel frame, metal siding, windows and doors; and the addition of an equipment elevator with enclosure to serve the south side of F-10. The installation of the metal panels on F-10 and F-10B will protect the brick from further deterioration. The enclosure of the metal stair will complete the safety covering of the major exits from the building second floor and reduce heat loss. The elevator will permit movement of equipment between the laboratories within the south wing of the building.

4. Repair Exterior, Central Heating Plant, Building D-8 280,000

This project provides for the repair of the exterior brick wall at Central Heating Plant, Building 8. The work includes the installation of metal furring, metal panel siding, flashing, and trim; removal of existing steel windows; and the installation of new ventilating windows. The existing building was built in 1944 and the exterior brick facing has deteriorated causing water infiltration. The installation of metal siding will prevent further deterioration and provide water protection. The existing ventilation windows are inoperable and require replacement.

5. Repair of Roofs on Buildings D-1 and N-159 300,000

This project provides for the repair of the roofs on the north and south sides of building D-1 and east side of Building N-159. The work includes the replacement of the existing built-up roofs with an elastomeric membrane system, including insulation, flashing and coating. The north and south wings of Building D-1 house Aeronautical Operations and Facilities Engineering; the East wing of N-159 houses Observational Science personnel and laboratories. Both roofs have a history of leaks, wet insulation, ponding, and drainage problems. This project will remedy the defects and reduce maintenance costs.

M. Various Locations $1,500,000

1. Repair Operations and Support Building, Bermuda Tracking Station . . . $800,000

This project replaces one 55-ton water chiller serving the Operations and Support building with a new 100-ton chiller. Construction of a twenty foot by eighty foot building enclosure is also provided. The project also includes the construction of two 990 square foot additions to the building for operations and extension of the existing electrical system and

heating, ventilating and air conditioning system. Other repairs include correction of hurricane damages to various exterior entrances, reconstructing 12 wooden vestibules with masonry, replacement of storm damaged windows, and installation of masonry windbreaks to protect the drum storage area. Bermuda experiences direct hits from hurricanes approximately once every five years. The chilled water system was installed in 1965 and has deteriorated because of age and the corrosive saline environment.

2. Repair Roads, Goldstone, California 300,000

The project will provide for the resurfacing of all pavements at the DSS 13 Venus site. It will provide flood control for the site and its access road. Paving an additional parking area around the 34-meter antenna is necessary to meet current requirements. The existing access road to the 34-meter beam waveguide antenna at the Venus site and buildings requires protection against flash flood waters. Paving at DSS 13 is about 25 years old, is cracked and worn out, and requires resurfacing.

3. Repair Roads, Madrid Spain 400,000

This project provides for deteriorated pavement repair and resurfacing of on-site roads, parking lots and antenna aprons at the Madrid Deep Space Communications Complex. Surface drainage problems will be corrected. Resurfacing will be composed of approximately two inches of hot mix asphalt concrete and includes the sealing of antenna aprons. Deficiencies in the existing drainage control system will be corrected to avoid more costly future repairs. The road surface has deteriorated and must be repaired to prevent major pavement failure.

N. Miscellaneous Projects Not In Excess of $250,000 Each . . . . . $ 500,000

Total $36,000,000

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

Approximately $50 million per year will be required for continuing repair needs.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1994 ESTIMATES

SUMMARY

REHABILITATION AND MODIFICATION

Summary of Project Amounts by Location:	Amount	Page No.
Ames Research Center	$3,910,000	CF 14-3
Dryden Flight Research Facility	680,000	CF 14-4
Goddard Space Flight Center	3,730,000	CF 14-5
Jet Propulsion Laboratory	2,300,000	CF 14-6
Johnson Space Center	2,900,000	CF 14-7
Kennedy Space Center	3,370,000	CF 14-9
Langley Research Center	3,770,000	CF 14-10
Lewis Research Center	3,500,000	CF 14-11
Marshall Space Flight Center	4,050,000	CF 14-12
Michoud Assembly Facility	1,800,000	CF 14-14
Stennis Space Center	2,350,000	CF 14-14
Wallops Flight Facility	2,200,000	CF 14-15
Various Locations	1,220,000	CF 14-17
Miscellaneous Projects Not in Excess of $250,000 Each	220,000	CF 14-17
Total	$36,000,000	

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1994 ESTIMATES

PROJECT TITLE: Rehabilitation and Modification of Facilities, Not in Excess of $1,000,000 Per Project

INSTALLATION: Various Locations

FY 1994 CoF Estimate: $36,000,000

FY 1992: $34,800,000 FY 1993: $34,000,000

COGNIZANT INSTALLATIONS/LOCATIONS OF PROJECT: Various Locations

COGNIZANT HEADQUARTERS OFFICE: Office of Management Systems and Facilities

SUMMARY PURPOSE AND SCOPE:

These resources will provide for the rehabilitation and modification of facilities at NASA field Installations and Government-owned industrial plants supporting NASA activities. Included in this request are those facility rehabilitation and modification needs for FY 1994 that have been fully identified at the time of the submission of these estimates and are estimated not to exceed $1,000,000 per project. The purpose of this program may include some restoration of current functional capability but also includes enhancement of the condition of a facility so that it can more effectively accomplish its designated purpose or increase its functional capability.

PROJECT JUSTIFICATION:

The NASA physical plant has a capital investment of $4.9 billion and has a current replacement value of more than $15 billion. A continuing program of rehabilitation and modification of these facilities is required to accomplish the following:

a. Protect the capital investment in these facilities by minimizing the cumulative effects of wear and deterioration.

b. Ensure that these facilities are continuously available and that they operate at peak efficiency.

c. Improve the capabilities and usefulness of these facilities and thereby mitigate the effects of obsolescence.

d. Provide a better and safer environment for all personnel.

This program includes only facility rehabilitation and modification work having an estimated cost not in excess of $1,000,000. The work is of such a nature and magnitude that it cannot be accomplished by routine day-to-day facility maintenance or by related routine facility work efforts that are provided for in other than CoF estimates.

PROJECT DESCRIPTION:

Proposed rehabilitation and modification projects for FY 1994 totaling $36 million are described under "PROJECT COST ESTIMATE." The total program of $36 million has been distilled from requests of more than $65 million and represents only a modest request in relation to the backlog of this type of work. Based on relative urgency and expected return on investment, the projects that comprise this request are the highest priority requirements. Deferral of this mission-essential work would adversely affect the availability of critical facilities, program schedules, and energy-conservation objectives. Only those projects estimated to cost not in excess of $250,000 have not been described individually or identified by center. The total cost of these miscellaneous projects is $220,000.

During the course of the year, some rearrangement of priorities may be necessary. This may force a change in some of the items to be accomplished. Any such change will be accomplished within available resources. The following broad categories of work are described further in the "PROJECT COST ESTIMATE":

a.	Utility Systems	$12,400,000
b.	Fire Detection/Protection Systems	820,000
c.	General Purpose Buildings	12,450,000
d.	Technical Buildings/Structures	10,330,000

PROJECT COST ESTIMATE:

A. Ames Research Center (ARC) $3,910,000

1. Rehabilitation and Modification of Space Flight Environmental Simulator 52-Ft Centrifuge (N-239A) 900,000

This project provides for adaptation of this simulator for human research purposes while retaining original capability for animal research. It includes demolition of existing equipment, construction of human research enclosures, control room modifications, and ingress/egress modifications. This facility will provide the only United States capability for long term (up to one year) human continuous gravity investigation with a large radius device. It will expand and continue NASA's research capability in human response to artificial gravity.

2. Rehabilitation and Modification of Security Office, Building 15 900,000

This project provides for rehabilitation of a 20,000 gross square foot building, including installation of air conditioning and fire protection, and modification of heating and ventilation, electrical, lighting, and building layout. This building was originally built as a fire station and is now used as the security office. It contains neither air conditioning nor fire protection, and the electrical system does not meet current code. It is not adequate for use as a security office.

3. Modify Communications Underground Duct Network 360,000

Expansion and repair of the existing communications duct network are included in this project, which consists of trenching and installation of duct banks and manholes. The existing ducts are filled to capacity and are damaged in some areas. Duct bank capacities have been exceeded due to use of personal computers and extensive networking demands. New duct banks are needed to meet center communications requirements.

4. Rehabilitation and Modification of Fire Sprinkler System (N-239) 600,000

This project provides a new wet pipe automatic fire sprinkler and alarm system in Building N-239. Smoke detectors and alarm connections to the sprinkler, water flow, and valve tamper devices will also be provided, as well as new exterior water lines from the water mains to the building. This 126,000 gross square foot office and laboratory building is currently without sprinklers and must be upgraded to meet current NASA fire protection requirements. The existing alarm system has reached the end of its life and must be replaced.

5. Modify 80 X 120 Ft Wind Tunnel Power Supply for Model Utilities, N-221B 550,000

This project includes modification of model utilities consisting of installation of a transformer in a unit substation to provide greater capability for model utilities power. Also, a feeder line from an Ames substation to the unit substation will be added. Power is presently not adequate to support individual mechanical systems, such as hydraulics, model air, model lubrication, and jet engine starts. Test objectives are now routinely limited due to lack of power. Ames is currently renting generator equipment that is neither adequate nor cost effective. Continued use of the 80 X 120 without this project prolongs inefficient operation and unnecessarily limits test program objectives.

6. Rehabilitation of Air Dryers, N-229A 600,000

The air dryers on the lines from the 3,000 psi high-pressure air system to the 3.5-ft Hypersonic Wind Tunnel will be replaced in this project. Included are modifications to high-pressure air plumbing, provision of electric power for regeneration of dryer beds, and control and monitoring systems integration. The air dryers have exceeded their useful life, and maintenance downtime is causing slippage of research projects.

B. Dryden Flight Research Facility (DFRF) $680,000

1. Rehabilitation and Modification of Backup Power System, Building 4875 330,000

This project provides for replacement of an existing 60 kilowatt (kW) generator with a 400 kW generator with connections to an existing 225 kV (kilovolt) uninterruptible power supply (UPS) at the UPS Facility. The 60 kW generator backs up facility telephone equipment and is not adequate. Existing commercial power is unreliable and numerous power outages have caused telephone equipment failures.

2. Modifications for Communications Complex Backup Power, Building 4824 350,000

Provide and install 225 kilovolt amps of uninterruptible power supply with 15 minutes of battery back-up. Provide weather-proof enclosure for batteries and rectifiers. Provide all wiring and controls to connect to existing systems. This complex provides radio frequency mission communications for aeronautic research missions and supports Space Transportation System Landings at Edwards, Air Force Base. It is essential that 15 minutes of uninterruptible power be provided, or critical computer programs will be damaged or lost.

C. Goddard Space Flight Center (GSFC) $3,730,000

1. Modification to High Bay White Room, Building (2) 900,000

This project provides for modification of approximately 5,000 sq. ft. of the High Bay Staging Facility. The modifications include upgrading the area to a class 100,000 clean room, installation of a three-ton overhead bridge crane, and providing mechanical equipment to support clean room and laboratory operations. This project will also provide for the construction of a 1,000 sq. ft. laboratory addition adjacent to the high bay room. The laboratory will include a hoist for transporting experiments and instrumentation to the high bay area. Electrical, architectural, fire protection and detection systems will also be modified and included as required. These high bay modifications are essential to meet the flight cleanliness requirements of the next generation of instruments being proposed for cosmic ray and gamma ray space research. Continued development of these instruments in a cost-effective manner is dependent on this facility capability.

2. Rehabilitation of Utility Control System 480,000

This project will replace obsolete portions of the existing Utility Control System (UCS) for Buildings 6, 24, and 28 with a state-of-the-art Direct Digital Control UCS system. Pneumatic automatic temperature controls and sensors will be replaced with new digital systems to provide reliable inputs and independent local control of air conditioning systems. This project is critical to providing effective energy conservation. The existing obsolete UCS is primarily a monitoring system and has incurred numerous operational problems such as software failures and inaccurate sensor inputs. The new digital system will provide for an efficient, reliable, and maintainable air conditioning control system.

3. Rehabilitation and Modification of Terrestrial Applications Facility, Building (22) 650,000

This project provides for the renovation of approximately 11,000 square feet of space in Building 22 to accommodate new occupants. Modifications include the conversion of computer and other technical space into offices and new computer space, and the reworking of existing office space. Project work includes the relocation of wall partitions, HVAC systems, ceiling systems, floor tiles, and wall finishes as required. Rehabilitation of lighting, smoke detection and sprinkler systems is included. This project is an essential element in the Center's overall housing plan. Consolidation of organizations and like activities to promote operational efficiency are key tenets of this plan.

4. Rehabilitation and Modification of Technical Support Building (20) . . 900,000

This project proposes the rehabilitation of approximately 7,000 square feet of existing laboratory, office, and support space in the north end of the Technical Support Building, Building 20. The project includes demolition of existing partitions, flooring and ceiling systems, and associated mechanical and electrical systems. The project will install new partitions configured to meet user needs; new flooring and wall and ceiling finishes; will reconfigure mechanical ductwork/diffusers and electrical service distribution; and will replace lighting systems and provide new fire detection and suppression systems, as required. The project will also provide a new mezzanine containing approximately 5,600 square feet of office and support space, along with necessary services (including additional restroom facilities, fire egress stairs, and an elevator, as required). This project will assist the Center in implementing its overall housing plans and reflects consolidations that have taken place as a result of a recent reorganizations.

5. Modifications to Buildings 3/14 for Missions Operations Facility . . . 800,000

This project will modify approximately 10,000 square feet of space in Building 3/14 for the mission operations systems. Included is the installation of new ceiling, light fixtures, partitions, acoustical treatment and raised floor tiles. Modifications will be made to the heating, ventilating, and air conditioning system, fire protection and detection system, and electrical service. This work is required to reconfigure and upgrade space to integrate and accommodate personnel and support systems for expanding missions.

D. Jet Propulsion Laboratory (JPL) $2,300,000

1. Modification for Analytical Chemistry Laboratory (67) 800,000

This project provides for the renovation and upgrade of this two-story, wood-framed laboratory building to include a complete heating, ventilation and air conditioning system; new lighting; and an electrical upgrade to bring the facility into compliance with building codes. Structural changes will be made to accommodate functional needs for the facility. Temperature and dust controls will be included for the laser laboratories. Painting, replacement of ceilings, and new flooring is included as is installation of user-furnished fume hoods, cabinets, and work surfaces. Sinks and plumbing that are either obsolete or leaking will be replaced. Laboratories that have unwanted windows will have the windows removed and the openings sealed. Existing restrooms will be brought into substantial compliance with standards for the disabled.

2. Modification for Waste Water Recovery, Microdevices Laboratory (302) 700,000

This project will modify the current waste water treatment system to remove concentrated dissolved solids from the discharge wastewater stream of the existing reverse osmosis water treatment system servicing the building. The solids will be separated by a centrifugal separator and trapped in a closed-circuit filter that can be removed and disposed of as non-hazardous solid waste. The current system discharges 30 to 50 gallons per minute on a continuous basis. Treatment of the waste discharge and recycling it to the cooling towers for make-up water will substantially reduce (approximately 13 to 20 million gallons per year) the Laboratory's sewer flow and reduce the use of city water by the same amount.

3. Modifications of Restrooms, Telecommunications Research Laboratory (238) 800,000

This project will modify and upgrade the existing restrooms. On floors 2 through 7, the men's restrooms will be expanded to provide handicapped accessibility. The women's restrooms on floors 3, 5, and 7 will be relccated, and women's restrooms will be added on floors 2, 4, and 6. A shower will be added to each restroom on the second floor. Handicapped accessibility requirements will be incorporated into the restrooms. The project will include new plumbing fixtures, toilet accessories, light fixtures, showers, toilet partitions, urinal screens, ceramic tile floors and walls, doors, and painting. The ventilation system will be modified. There were no provisions made for women's restrooms on floors 2, 4, and 6 when the building was constructed in 1965. Female occupancy of the building has increased and is anticipated to continue. The existing restrooms do not provide accessibility for handicapped people.

E. Johnson Space Center (JSC) $2,900,000

1. Upgrade Potable Water Pumping System, Building 322 650,000

This project provides for the modification of the existing potable water pumping system to increase the pumping capacity. The work includes replacement of the existing pump and the addition of a new 1,500 gallon per minute (GPM) pump. Other modifications include replacing the motor control center and transformer with those of greater capacities, installing a new electrical manhole and gas switch, installing an air conditioning window unit for humidity control, and a 190 square foot addition to the Water Treatment Plant Building to house the new switchgear and motor control center. A recent study indicated that the existing potable water pumping system will not be able to keep up with projected water demands for fire protection, domestic, and industrial uses unless these upgrades are completed.

2. Upgrade Sanitary Sewer System 550,000

This project provides for modifications to the sanitary sewer system. The work includes installing a new lift station to serve the 300 and 400 areas and the installation of approximately 4,000 linear feet of 18-inch force main. This project is required to meet additional demands on the system caused by the addition of several new facilities.

3. Rehabilitate Air Conditioning System, Building 30E 800,000

This project provides for the rehabilitation of the mechanical and electrical systems in the administration wing of the Mission Control Center, Building 30. The work includes installation of a new energy-conserving variable air volume system. Associated electrical modifications include installation of new lighting fixtures and switches along with spot asbestos abatement. The air conditioning and associated lighting system must be rehabilitated to provide for an efficient, reliable, and maintainable energy-conserving system.

4. Rehabilitate Mechanical Systems Support Buildings 100 Area, White Sands Test Facility 600,000

This project provides for repair, refurbishment, and/or replacement of major heating, ventilating, and air conditioning (HVAC) systems in Buildings 110, 111, 112, 113, 114, 120, and 121. These are support buildings in White Sands Test Facility (WSTF) 100 Area. Work will replace obsolete equipment, include asbestos abatement, and provide control modifications for energy conservation. HVAC systems include air handling units, chillers, direct expansion refrigeration equipment, air distribution components, humidifiers, and control systems.

5. Modification of Equipment Receiving Enclosure (7) 300,000

This project provides for modifications to an existing equipment receiving enclosure on the Crew Systems Laboratory, Building 7. The work includes the upgrade of the existing area by providing a chilled water and steam cooling and heating system for the area, adding a new exterior wall along the west side of the enclosure, weather sealing and insulating the area, upgrading the ceiling and floor, and correcting drainage problems in the general area. The project is required to provide a productive working environment to support development and pre-test checkout activities associated with extravehicular activity assembly operations and to support development testing of Lunar/Mars life support systems.

F. Kennedy Space Center (KSC) $3,370,000

1. Replace Piping Systems,
Utility Annex to Orbiter Processing Facility 900,000

This project provides for replacing existing buried high temperature hot water, chilled water, and compressed air lines between the utility annex and the Orbiter Processing Facility (OPF) with lines installed above ground except at road crossings. The existing lines are very deteriorated from ground-water intrusion. Failure to provide reliable piping systems could result in loss of utility service to the OPF, impacting shuttle orbiter processing.

2. Renovate Occupational Health Facility East Wing Interior 500,000

This project provides for renovation of approximately 14,000 square feet of the Occupational Health Facility (OHF) to make the existing facility more efficient. Treatment rooms, nurses' station, triage area, records storage, physicians' examing rooms, preventive medicine, and other support space will be expanded and rearranged to afford efficiency and privacy for patients. Increased medical services workload for Kennedy Space Center has greatly impacted the OHF capacity to provide physical examination and treatment functions. The number of physical examination requirements have increased dramatically over the past five years, which has compounded the current problem.

3. Replace LC-39 Pads A & B Air Handlers 740,000

This project provides for replacement of four air handlers in the Pad A Pad Termination Connection Room (PTCR) and four air handlers in the Pad B PTCR. Work also includes asbestos removal; replacement of piping, valves, and controls; and required electrical modifications. The air handling units are 25 years old and the presence of asbestos makes proper maintenance difficult or impossible. Failure of these units will impact launch-sensitive areas of the second floor PTCR and first floor vehicle UPS unit.

4. Modify Hangar AM Air Conditioning System, Cape Canaveral 590,000

This project will upgrade the air conditioning system in Hangar AM to assure proper environmental control. Two existing chilled water loops will be connected as one system to provide redundancy in the high bay cleanroom. The cooling tower, air handling unit (AHU), and controls will be refurbished and upgraded. An existing 25-ton AHU and controls will be replaced in the office areas. The existing 50-ton chiller and associated pumps and controls will be replaced. These modifications will correct the inefficient operating mode and reduce the dependency on temporary chillers.

5. Modify Hydraulic Surge Capacity 640,000

This project provides for installation of a 100,000 gallon capacity sewage surge retention facility. Work also includes new pumps, aeration system with associated piping, and electrical modifications. The increased load on the sewage treatment plant due to present and planned new construction necessitates the installation of this surge capacity. Once installed, the plant operators will control flow at a constant design flow and hold peak accumulated sewage for treatment at low-flow periods.

G. Langley Research Center (LaRC) $3,770,000

1. Modifications to Office Space (1192) 840,000

This project provides for modifications to Building 1192 to house computational research personnel; advanced, state-of-the-art computer equipment; and the Fluid Mechanics Division Office. The modifications consist of constructing new office spaces; replacing the lighting, ceiling, floor tiles, and wall finishes; and providing additional electrical power to support the computer equipment. The restrooms and air conditioning system will also be upgraded to current standards. The modified space will be used by research personnel, computer equipment, and office staff. This project will result in disposal of three existing inadequate and costly to maintain trailers currently used to house these functions.

2. Rehabilitation of General Rotor Aeroelasticity Laboratory (647) 900,000

This project provides for rehabilitation and modification of the General Rotor Aeroelasticity Laboratory located in Building 647 of the East Area. The rehabilitation provides replacement of ceilings, lights, wall finishes, and floor tiles in the high bay area, control room, office, lab areas, and shop area. The modifications include constructing an enclosure for an existing mobile hydraulic pump stand, construction of an interior room for model assembly, and upgrade of restrooms. The project also includes replacement of approximately 22,500 square feet of corrugated transite roofing panels with an insulated, pre-finished, corrosion resistant, standing seam sheet metal roof system. This project is essential to restore the proper environmental and operational conditions to support the model setup, checkout, and calibration before testing in the Transonic Dynamics Tunnel.

3. Modifications to the 20-Inch Supersonic Wind Tunnel (1247D) 900,000

The modifications included in this project are a new closed-loop controlled model support system with injection/retraction and projection capability; modification and reuse of the existing variable second minimum and diffuser section from the Langley 6- by 28-Inch Transonic Wind Tunnel; installation of a quick-acting, retractable test cabin door; and a new exhaust line to the 100-foot sphere 5-foot vacuum duct. Implementation of this project is

necessary to meet research schedules and to improve the versatility of the only small, high-flow-quality supersonic facility at Langley Research Center.

4. Modifications to Thermal Acoustic Fatigue Apparatus (1221A) 730,000

This project provides for the modification to the Thermal Acoustic Fatigue Apparatus (TAFA) located in Building 1221A. The project includes modifications to the air supply and regulator to accommodate new acoustic sources; additional acoustic sources to provide a 6 dB increase in the noise level and improved spectrum shaping capability; a new horn to couple the acoustic sources to the test section; modification of the downstream termination section; new removable water-cooled inserts in the test section to reduce the area from 1′ x 6′ to 1′ x 2′; and new removable inserts in the horn and transition sections to match the test section reduction. These modifications will provide a significant extension of test capability and permit the acquisition of dynamic response and sonic fatigue data over a larger proportion of the aerospace vehicle flight envelope. These modifications will also correct several acoustic deficiencies identified in a recent engineering study of the facility.

5. Modifications to Shipping and Receiving Building (1206) 400,000

The work provided in this project includes expanding the main shipping/receiving loading dock; installing an additional hydraulically operated loading ramp; upgrading the restrooms; constructing new office space; replacing four existing roll-up doors and installing one new roll-up door; and upgrading the heating, ventilating, and air conditioning system for existing offices. The modifications will improve efficiency and safety in the shipping/receiving area and free much needed warehouse floor space for warehouse operations.

H. Lewis Research Center (LeRC) $3,500,000

1. Rehabilitation of Electrical System, Building (86) 900,000

This project provides for the rehabilitation of the electrical system in the 10x10 Supersonic Wind Tunnel Office and Control Building (86). The work includes upgrading the power distribution system; lighting system rework with high-efficiency fixtures; replacement of fan coils and HVAC with tie-in to the Utility Control System (UCS); and installation of lighting fixtures, exit/emergency lights, and smoke detection systems. This building is underpowered and lighting is inefficient and inadequate. This project will upgrade the electrical system to comply with present codes and provide sufficient power and efficient lighting for this facility.

2. Rehabilitation of Mechanical and Electrical Systems (105) 850,000

This project will provide new variable volume heating, ventilating, and air conditioning (HVAC); perimeter heat; and controls in the Materials Processing Lab (105). In addition, the electrical power distribution system will be upgraded and the lighting will be replaced with modern fixtures. As part of this project, asbestos will be removed from piping and mechanical components. The existing HVAC was installed in 1959 and requires constant repair. This project will upgrade the electrical and mechanical systems to comply with present codes and provide sufficient power and lighting for the building.

3. Rehabilitation of Mechanical and Electrical Systems (301) 850,000

This project provides for the rehabilitation of the heating, ventilating, and air conditioning (HVAC) and lighting in the office section of the Electric Power Lab (EPL), Building 301. The work includes replacement of the lighting fixtures, chiller, heat exchanger, pumps, piping, HVAC units, control, and associated architectural and electrical work. The existing system was installed in 1961 and has experienced deterioration in condition and performance. The new mechanical and electrical systems will provide an efficient, reliable, and economical HVAC system for the EPL offices.

4. Rehabilitation of Mechanical System (302) 900,000

This project provides for replacement of the existing undersized chillers in the Energy Conversion Lab (ECL), Building 302 with two new 100-ton capacity chillers and associated controls. In addition, a new 200-ton cooling tower and associated pumps, piping and controls will be installed. The electrical power will also be upgraded to support the new mechanical systems. The existing 30-year-old chillers are undersized and inefficient for air handling needs of the air conditioning system.

I. Marshall Space Flight Center (MSFC) $4,050,000

1. Rehabilitate Industrial Water System 800,000

This project provides for the replacement of approximately 300 linear feet of 42-inch diameter water distribution lines and associated valves in the West Test Area. The Industrial Water System is critical to the operation of the test stands in this area. The piping to be replaced is severely corroded, the valves do not seal properly, and it is not economical to continue piecemeal repairs. The new water distribution line will be routed above grade rather than below grade to improve accessibility and maintainability, and to reduce the schedule impact to the ongoing test operations.

2. Rehabilitate and Modify Diesel Cooling System 900,000

This project provides for the rehabilitation and modification of the diesel engine cooling water system at the West Test Area pumphouse. Existing heat exchangers will be restored and independent cooling pumps will be added to each diesel cooling system to assure adequate cooling water flow under all operating conditions. The existing heat exchangers are deteriorated and heavily corroded. The lack of flow through the heat exchangers is causing overheating and subsequent shutdown of the diesel engines during Test Area operations. This project significantly reduces the risk of a Test Area shutdown, and reduces operations and maintenance costs.

3. Modifications for Precision Optical Metrology and Assembly (4487) . . . 900,000

This project provides for the refurbishment of the east end of the laser tube adjacent to B-Wing. Work includes installation of heating, ventilation, and air conditioning (HVAC) and class 100K filters. Fixture storage and entrance areas will be added; interior area will be refinished to minimize out-gassing and dust contamination. An existing crane will be refurbished or replaced to meet clean room requirements. This project also provides for the construction of an approximately 2,200 square foot addition at the west end of B-Wing to support the 30-foot precision optical metrology vacuum chamber. A covered dock with a 1-ton monorail will be installed. All areas will require high purity air and power distribution for support equipment. Precision optical metrology, assembly, and test facilities are critical for support for multi-program (i.e., Advanced X-Ray Astrophysics Facility (AXAF), Optical Payloads) optical research and testing.

4. Modifications to Space Station Engineering and Development Building (4755) 600,000

This project provides for modifications which consist of converting approximately 7,000 square feet of central high bay area into a two-story office area. The first floor will include a new main entrance lobby, an entry air-lock, administrative offices, and a large conference room. The second floor will consist of offices and engineering support areas for Center support personnel. This facility has been designated as the development area for the environmental control and life support system test bed for Space Station Freedom. All test and verification of program development hardware for the laboratory and habitat modules in advance of on-orbit assembly is taking place in this facility. This project addresses a shortfall of space to house the test and development personnel assigned to support the test program development.

5. Rehabilitate Exterior of Office Building (4746) 850,000

This project provides for the rehabilitation of Building 4746. Work includes providing thermal protection to exterior walls by installing insulation, face brick, and new glass windows. Also included is the installation of a new sloped metal roof system over the existing flat roof and modification of the building entrances. Building 4746 is a 50-year-old, 18,300 square foot facility that was originally designed as a medical clinic but is now being used as an office building. This project will upgrade the facility to comply with current handicapped and building code standards, and provide an energy-efficient and low-maintenance building envelope.

J. Michoud Assembly Facility (MAF) $1,800,000

1. Rehabilitate East Chilled Water Return Piping 900,000

This project provides for the restoration and upgrade of approximately 6,000 linear feet of overhead chilled water return piping in the External Tank Main Manufacturing Building. The new piping will be routed to improve accessibility and maintainability. Work to be done also includes the replacement of existing valves, or the addition of new valves, as required. The chilled water return system was originally installed in the 1940s and is very deteriorated. Pipe wall thickness has decreased by 50 percent in some areas due to severe corrosion, and current configuration does not provide sufficient valves to adequately isolate problem areas during outages. Lack of easy access to piping makes piecemeal repairs difficult and costly.

2. Rehabilitate and Modify Substation No. 24 900,000

This project provides for the replacement of the existing equipment with two 1,500 KVA transformers, associated switchgear, and a housekeeping pad. Substation No. 24 is 26 years old, difficult to maintain, and constantly overheating. The substation provides power for medical facilities, security and radio communication systems, and a cooling tower. It can no longer meet these requirements in its present configuration because of substantial load increases since its original installation.

K. Stennis Space Center (SSC) $2,350,000

1. Rehabilitate SSME Engine Assembly Building (3203) 630,000

This project provides for the rehabilitation of the Space Shuttle Main Engine (SSME) Assembly Building heating, ventilating and air-conditioning (HVAC) systems and associated pneumatic/electrical and Utility Control Systems (UCS). The existing HVAC systems and pneumatic controls are more than 25 years old, difficult to maintain, require high-cost replacement of parts, and have exceeded their 20-year normal life expectancy.

2. Modify Utility Control System 820,000

This project provides for the modification of the Utility Control System (UCS) and the heating, ventilating and air conditioning (HVAC) systems at the Visitors' Center (B-1200), the Data Handling Center (B-1000), Water Well and Pump House #1 (B-3312), and the Lock Water Supply Pump Station (B-2311). Work includes the replacement of the pneumatic controls and refurbishment of the air handling units. The existing UCS and HVAC systems are more than 20 years old and no longer can provide the full control and energy savings that could be achieved by a replacement system.

3. Rehabilitate 13.8KV Electrical Distribution System 900,000

This project provides for the rehabilitation of the switching capabilities of the 13.8kV electrical distribution system. Work includes the conversion of existing oil switches to modern gas insulated swithes. The existing oil switchgear is antiquated, difficult and costly to maintain, and several are leaking or taken out of service thereby limiting the original capability.

L. Wallops Flight Facility (WFF) $2,200,000

1. Modifications to the Heating, Ventilating, and Air Conditioning (HVAC) Systems in Buildings E-107 and E-108 470,000

This project provides for modification of the HVAC systems in Buildings E-107 and E-108. The work includes installing louvers, exhaust fans, air handling units, refrigeration equipment, new duct work, supply air diffusers, return air registers, piping and control valves, and temperature and humidity controls; modification to outside air duct works; and testing and balancing of both the air and water flows to each floor of the two buildings. The present HVAC systems are undersized in capacity resulting in condensation collecting on the supply air diffusers, unbalanced air flow, mold and mildew problems, and irregular temperatures (hot and cold spots) throughout each building. The modification of these systems will provide adequate cooling, heating, air flow, humidity and temperature control for equipment and personnel.

2. Rehabilitation of Launch Vehicle Support Building (X-35) 530,000

This project provides for the rehabilitation and modification of 8,100 square feet in Building X-35. It requires the installation of a 2,500 square foot metal partition; vinyl backed R-19 insulation with an 8 foot perimeter liner; heating system; power panel, outlets and lighting; restrooms; 7.5 ton bridge crane; 15-ton fixed hoist with footings and columns; 1,600 square foot enclosed area with a storage mezzanine and stairs; and the relocation of the air

compressor to an external shelter. The rehabilitation of Building X-35 is required to provide adequate space for sounding rocket launcher modifications and maintenance. This includes various size launchers for use on Wallops Island, at remote ranges, and other mobile sites.

3. Modification to Vehicle Assembly Building, White Sands Test Facility, New Mexico 330,000

This project provides for the modification to the Vehicle Assembly Building at White Sands Test Facility. The work includes the installation of a fire protection system for the entire building, including a 25,000 gallon steel ground storage tank; concrete foundation; pre-fabricated metal shed; fire pump; piping and wet pipe sprinkler system; packaged heat pump; mechanical controls and electrical wiring for the HVAC system; the removal of an overhead door; construction of wall partition; interior finishes; and the installation of personnel doors in the altitude control system area. The current Vehicle Assembly Building was constructed in the 1960s and provides for the integration and testing of payloads launched at the White Sands Missile Range. Modifications will permit expansion of the altitude control system alignment area, provide a controllable environment for operations, and upgrade the facility to meet current code requirements of fire, safety, and protection for a mission critical facility.

4. Rehabilitation of Assembly Shop Building (W-15) 320,000

This project, which provides for the rehabilitation of Building W-15, includes the demolition of interior partitions; raising the main floor elevation with 6 inches of concrete; paneling interior perimeter of the exterior walls; sand blasting and refinishing the vehicle shelter; installation of fire protection; thermal windows/doors; and an insulated overhead door. This building was originally built for vehicle assembly and check out, but was modified into a machine shop and storage area for the Scout program. This rehabilitation will convert the building into an assembly shop in support of the increased number of vehicles in the Sounding Rocket Program.

5. Rehabilitation of Materials Storage Building (B-31) 550,000

This project provides for the rehabilitation of the Material Storage Building (B-31). The work includes the removal of the original roof and support structure, interior wood partitions, wood windows, personnel and overhead doors, and floor tile. Also included is the installation of structural steel support roof system covered with an elastomeric membrane; overhead and personnel doors; cleaning and painting interior and exterior masonry walls; thermal windows; heating; lighting and electrical service; pad mounted transformer; and a fire protection system. The current materials storage building has had minimal rework since it was constructed in 1945. New material and systems will stop the deterioration and leakage of the building, and provide the needed protection and security for high-cost maintenance vehicles and equipment.

M. Various Locations $1,220,000

1. Modification of 70-Meter Antenna Foundation, Canberra, Australia 500,000

This project provides a reinforced concrete ring foundation for support of the antenna to allow maintenance and repair of the hydrostatic bearing system. The hydrostatic bearing system, which allows the antenna to rotate, has deteriorated. Unless repaired, operation of the antenna will halt, and all tracking will be lost.

2. Modification of 70-Meter Antenna Foundation, Madrid, Spain 360,000

This project provides a reinforced concrete ring foundation for support of the antenna to allow maintenance and repair of the hydrostatic bearing system. The hydrostatic bearing system, which allows the antenna to rotate, has deteriorated. Unless repaired, operation of the antenna will halt, and all tracking will be lost.

3. Modification of 70-Meter Antenna Foundation, Goldstone, California 360,000

This project provides a reinforced concrete ring foundation to be used for support of the antenna to allow maintenance and repair of the hydrostatic bearing system. The hydrostatic bearing system, which allows the antenna to rotate, has deteriorated. Unless repaired, operation of the antenna will halt, and all tracking will be lost.

N. Miscellaneous Projects Not in Excess of $250,000 . . . . . $220,000

Total $36,000,000

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

Approximately $50 million per year will be required for continuing rehabilitation and modification needs.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1994 ESTIMATES

SUMMARY

MINOR CONSTRUCTION

Summary of Project Amounts by Location:	Amount	Page No.
Ames Research Center	$730,000	CF 15-3
Goddard Space Flight Center	720,000	CF 15-3
Jet Propulsion Laboratory	720,000	CF 15-3
Johnson Space Center	1,400,000	CF 15-4
Kennedy Space Center	2,070,000	CF 15-4
Langley Research Center	1,450,000	CF 15-5
Lewis Research Center	1,400,000	CF 15-6
Marshall Space Flight Center	1,400,000	CF 15-6
Michoud Assembly Facility	870,000	CF 15-7
Stennis Space Center	1,300,000	CF 15-7
Wallops Flight Facility	1,250,000	CF 15-8
Various Locations	445,000	CF 15-8
Miscellaneous Projects Not in Excess of $250,000 Each	245,000	CF 15-9
Total	$14,000,000	

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1994 ESTIMATES

PROJECT TITLE: Minor Construction of New Facilities and Additions to Existing Facilities, Not in Excess of $750,000 Per Project

INSTALLATION: Various Locations

FY 1994 CoF Estimate: $14,000,000

FY 1992: $12,900,000 FY 1993: $14,000,000

COGNIZANT INSTALLATIONS/LOCATIONS OF PROJECT: Various Locations

COGNIZANT HEADQUARTERS OFFICE: Office of Management Systems and Facilities

SUMMARY PURPOSE AND SCOPE:

These resources will provide for minor facility construction at NASA field Installations and Government-owned industrial plants supporting NASA activities. Each project in this program is estimated to cost no more than $750,000 and involves either the construction of new facilities or additions to facilities. The FY 1994 request of $14 million will improve the usefulness of NASA's physical plant by changing the utilization of or augmenting the capabilities of various facilities. Included in this request are those programmatic and institutional projects that are essential to the accomplishment of mission objectives.

PROJECT JUSTIFICATION:

The configuration of NASA's physical plant necessarily must respond to changes in utilization and adaptions required by changes in technology or in mission needs. Demands are generated by research, development, testing, and similar activities. Specific justification for each minor construction project is provided under "PROJECT COST ESTIMATE."

PROJECT DESCRIPTION:

Included in the FY 1994 minor construction program are those facility projects for institutional or technical facility needs that could be fully identified at the time of submission of this budget estimate. Items of work totalling $14 million are included in this resource request and have been distilled from a list totalling over $34 million. Projects were selected on the basis of the relative urgency of each item and the expected return on the investment. During the course of the year, the revision of priorities may require changes in some of the items to be accomplished. Such changes will be accommodated within the total resources allocated.

These projects represent requirements that must be met in this timeframe to support institutional needs and programmatic objectives. The following listing summarizes the cost distribution by category of work:

a.	General Purpose Buildings	4,395,000
b.	Technical Buildings/Structures	9,605,000

PROJECT COST ESTIMATE:

A. Ames Research Center (ARC) $730,000

1. Modification of Human Performance Research Laboratory (HPRL) High Bay (N-262) 730,000

This project provides for construction of a multi-storied structure within the existing high bay of the HPRL. The space will include laboratories, offices, shops, and general support area. This construction is needed to provide space for the Computational Human Factor Research Office, which will relocate from Building N-269. Research requires that this office relocate to be in proximity to laboratory and high-bay activities.

B. Goddard Space Flight Center (GSFC) $720,000

1. Construct Composite Materials Laboratory 720,000

This project provides for the construction of an approximately 4,900 square foot laboratory building near the northeast corner of the Instrument Construction and Installation Laboratory (Building 5). The facility will include a 1,100 square foot assembly area; a 1,000 square foot composite laboratory including a fume hood; a 940 square foot lay-up and cutting room; and a 400 square foot machining/surface preparation room. External to the facility will be an autoclave and a walk-in freezer. The remaining space includes 1,460 square feet of support functions such as restrooms and mechanical equipment rooms. The facility will also include provision of all required utilities. Site work includes storm water management and erosion control measures. The Composite Materials Lab will increase the capability to perform in-house composite materials research and development instead of using scattered off-site locations.

C. Jet Propulsion Laboratory (JPL) $720,000

1. Construct Flight Hardware Fabrication Addition (170) 720,000

This project provides for the construction of an approximately 2,000 square foot mezzanine over a portion of the existing Sheet Metal Shop for the fabrication and assembly of precision flight assemblies and subassemblies. This new enclosed mezzanine will be a class 100,000 clean fabrication and assembly area accommodating up to 10 technicians. The mezzanine will require a vestibule to serve the clean area and will be accessible to the handicapped. JPL is developing instruments for various planetary missions which, due to the instruments' increasing sensitivity, are required to be fabricated in a clean environment yet still be in proximity to the existing sheet metal shop.

D. Johnson Space Center (JSC) $1,400,000

1. Construct Laboratory Annex Building (14) 700,000

This project provides for the construction of an approximately 6,000 square foot addition to the Antenna and Tracking Development Laboratory, Building 14. The new annex will include laboratory and office space. This addition is required to support critical Space Shuttle tasks by relieving overcrowded and confined conditions. It will move researchers out of premium laboratory space and into suitable office space.

2. Construct Metrology Laboratory Addition, (343) 700,000

This project provides for the construction of an approximately 8,000 square foot addition to Building 343 for the Measurement Standards and Calibration Laboratory. The work includes providing a class 100 clean room, relocation of site utilities, heating, cooling, plumbing, electrical power, fire detection/suppression systems, a loading dock, and parking for 25 vehicles. This laboratory addition will eliminate the present overcrowding in the laboratory and provide a safe, state-of-the-art facility for calibration and repairs.

E. Kennedy Space Center (KSC) $2,070,000

1. Construct Hypergol Oxidizer Decontamination Facility 670,000

This project provides for the construction of a hypergol oxidizer rinsate recovery and processing facility. Work consists of demolition of existing storage transfer slip and equipment pad; construction of a new concrete slip with sump; construction of a new equipment slab; construction of a 3,750 sq. ft. minimum covered area for processing equipment and storage containers; and installation of tanks, fluid transfer components, manifolds and associated piping, and electrical modifications. Tanker and equipment rinsate have recently been categorized as hazardous waste. Activities for safing tankers, sampling melons, drums, components and flex hoses generate up to 20,000 gallons of hazardous waste a year. The cost of off-site disposal of this generated waste is very high. The activation of this decontamination and processing facility will reduce this generated waste to approximately 2,000 gallons and save operational costs.

2. Construct Transporter/Canister Facility Operations Support Bldg . . . 700,000

This project will provide space to be used by direct support personnel to the transporter/canister facility. The building will be approximately 5,200 sq. ft. It will provide office space for engineers and locker and break areas for technicians. A total of

approximately 45 people will be housed in this facility. Engineering is presently split between two trailers. To operate in a more efficient manner all personnel need to be in one area. A parking lot will be included as part of the project.

3. Construct Hydraulic Ground Support Equipment Building 700,000

This project provides for the construction of a two-story 30 ft. x 40 ft. building to house orbiter ground coolant and hydraulic system equipment. Work includes relocation of a portable page unit electrical power; relocation of fire hydrant and safety shower; installation of HVAC, power, and fire protection; and relocation of environmental control system ducts. This project is necessary because the current ground cooling and hydraulic portable equipment has deteriorated and is no longer able to support orbiter operations adequately. Fixed equipment which requires an environmental enclosure will be delivered in FY 1993. The building and equipment will be utilized on every orbiter flow through the Orbiter Processing Facility.

F. Langley Research Center (LaRC) $1,450,000

1. Construction of Activities Center Conference Facility Addition (1222) 730,000

This project provides for the construction of an addition of approximately 4,200 square feet to existing building 1222 for use as a conference facility. The conference area can be subdivided into four or five smaller areas by movable rigid partitions and includes a mechanical room, storage space, and connection to existing utilities and landscaping. The work includes the necessary modifications to the existing building to accommodate the addition, associated utility connections, parking, site improvements, and landscaping. The new addition will reduce the need for use of off-Center conference facilities and allow various configurations of the available space.

2. Construction of University Affairs Complex - Training Center 720,000

This project provides for construction of a single-story addition of approximately 4,800 square feet to the University Affairs Complex, Building 1216. The addition will be capable of accommodating a second floor and will include teleconferencing rooms, computer-oriented training room, conference rooms, and traditional classrooms. The project will include site improvements, landscaping, parking, and modifications to the existing facility and utilities as required to accommodate the addition. Construction of this facility will enhance the Center's capabilities to provide "state-of-the-art" computer training opportunities to present and future staffs.

G. Lewis Research Center (LeRC) $1,400,000

1. Construction of Office Addition, Chemistry Laboratory (6) 700,000

This project provides for the construction of an addition to the Chemistry Laboratory (6) of approximately 5,200 gross sq. ft. The one-story addition will be located on the southwest side of the building. Existing building systems will be modified or increased in capacity to support the addition. The design will allow for a future second floor addition. This building addition is required to provide the Aeronautics Directorate the necessary personnel space to relieve overcrowded and confined conditions in the existing Chemistry Laboratory Building.

2. Construction of Build-Up Area, Power Lift Facility (90) 700,000

This project provides for the construction of a new approximately 2,900 sq. ft. model build-up building. The building will have a build-up area serviced by an overhead crane, test article storage area, and restrooms. Work will include site modifications, HVAC, utilities, service air, mechanical, and electrical systems. Model build-up space is required to service the expanded needs resulting from activities of the Powered Lift Facility (PLF) and the Nozzle Acoustics Test Rig (NATR). This building will provide for the protection of test articles and hardware and facilitate improved production time and quality assurance by being located adjacent to the research rig.

H. Marshall Space Flight Center (MSFC) $1,400,000

1. Construct Addition to Aerophysics Building (4732) 700,000

This project provides for construction of an approximately 5,000 square foot addition to Building 4732. The addition will be built to match the existing facility, and will include required utilities, building systems, interior finishes, an elevator for handicapped access, and additional parking. The project also provides for incidental alterations/modifications to the existing facility required to accommodate the addition. Construction of this addition will allow all test and project engineers of the Aerophysics Division to be located within the same complex where their program test activities are performed.

2. Construct Addition for Network Communications (4207) 700,000

This project provides for construction of an approximately 5,000 square foot addition to Building 4207, including approximately 4,500 square feet of raised floor. The addition will be built to match the existing facility, and will include required utilities, building systems, and interior finishes. Redundant air-handling capacity and uninterruptible

power will be provided. The project also provides for incidental alterations/modifications to the existing facility required to accommodate the addition. Construction of this addition supports current and future mission communications requirements for all NASA locations.

I. Michoud Assembly Facility (MAF) $870,000

1. Construct Hazardous Waste Transfer Area (218) 450,000

This project provides for upgrading Waste Transfer Area 218 from a temporary storage area to a permanent storage area for hazardous waste. Work includes expansion of the containment area by approximately 2,500 square feet; installation of an eye wash, an emergency shower, an alarm system (pull station type), potable water lines, and lighting; construction of a roof structure over the containment area; and construction of a storage area for spill response materials. This project will improve safety and reduce operating costs associated with maintaining a short-term hazardous waste storage area in compliance with applicable Federal and State environmental regulations.

2. Construct Mezzanine in Facilities Operation Building (320) 420,000

This project provides for construction of an approximately 2,000 square foot steel mezzanine and alteration of approximately 6,000 square feet of existing space in Building 320. Work includes required utilities, building systems, and interior finishes. Building 320 houses security offices and vehicle shops. This project will significantly improve the functionality of the facility in support of these functions.

J. Stennis Space Center (SSC) $1,300,000

1. Construct Addition to Technical Contractor Building (2108) 650,000

This project provides for the addition of approximately 6,600 square feet of office building to the rear of Building 2108. The foundation will be a concrete slab-on-grade. Work includes gypsum wallboard on metal studs, ceramic tile in restrooms, suspended acoustical ceilings, vinyl tile, HVAC, plumbing, and electrical systems. This addition will consolidate the engineering and science department support contractors from eight locations, which will greatly enhance the productivity and capability in supporting program requirements.

2. Construct Addition to Engineering Services Building (2104) 650,000

This project provides for an approximately 3,400 square foot addition to the Engineering Services Building (2104). Construction will include a pre-engineered metal building on a concrete slab-on-grade with gypsum wall board, demountable partitions, suspended ceilings, HVAC, plumbing and electrical systems, a chilled water system, and an upgrade of the

existing system. The Engineering Services personnel work under crowded conditions and this addition will provide the professional environment required to support this organization.

K. Wallops Flight Facility (WFF) $1,250,000

1. Construct Rocket Storage Facility 720,000

This project provides for the construction of an approximately 8,000 sq. ft. Rocket Storage Facility on the north end of Wallops Island. The work includes sitework, excavation, concrete foundation and floor slab; erection of a pre-engineered metal building with insulated panels; overhead and personnel doors; electrical controls, lighting, heating, and ventilation; and high-low temperature alarm system with a communication line to Island Damage Control. This building will provide a rocket storage capacity that cannot be accommodated by any other facility on Wallops Island because of safety distance clearances. The building will be located in an isolated area on the north end of the island in order to satisfy safety criteria.

2. Construct Payload Fabrication and Integration Facility 530,000

This project provides for the construction of an approximately 4,800 square foot two-story metal building addition to the Sounding Rocket Fabrication and Text Complex at F-10. The work includes excavation and removal of existing concrete aprons; placement of new foundation and concrete floor slabs; the erection of a metal building addition with insulated wall and roof panels; second floor deck; finished walls, floors and ceiling; elevator; electric wiring and lighting; HVAC; fire protection system; and an overhead monorail (3-ton hoist capacity) on the first floor. During preparation for launch operations, the current facility does not provide adequate space for payload/experiment integration. This project will provide the needed addition of fabrication/laboratory space and will also provide room for two additional payloads to be integrated during peak periods.

L. Various Locations $445,000

1. Construct Perimeter Security Fences and Patrol Road, Madrid, Spain 445,000

This project provides for the extension of the perimeter fences and patrol road to surround additional land at the complex and includes approximately 1,650 meters of new complex perimeter road and approximately 2,375 meters of exterior wire-mesh fence suitable for intruder detection equipment. This project is required to enclose land to accommodate the planned FY 1993 34-meter Beam Wave Guide antenna and future antennas.

M. Miscellaneous Projects Not In Excess of $250,000 Each . . . . . $ 245,000

Total $14,000,000

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

Approximately $20 million per year will be required for continuing minor construction needs.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1994 ESTIMATES

SUMMARY

FACILITY PLANNING AND DESIGN

	Amount	Page No.
Master Planning	$ 800,000	CF 16-1
Sustaining Engineering Support	1,600,000	CF 16-2
Preliminary Engineering Reports and Related Special Engineering Support	4,000,000	CF 16-4
Final Design	20,600,000	CF 16-4
Total	$27,000,000	

68-668 O—93——23

PROJECT TITLE: Facility Planning and Design

FY 1994 CoF Estimate: $27,000,000

FY 1992: $27,880,000 FY 1993: $23,300,000

The funds requested in this estimate are required to provide for the following advance planning and design activities related to facilities activities and projects where not otherwise provided for:

a. The accomplishment of necessary studies, development and master planning for field installation and the provision of continuing engineering support and special engineering management and other services.

b. The preparation of preliminary engineering reports, cost estimates, and design and construction schedules. Also includes the preliminary engineering efforts required to initiate design-build projects.

c. The preparation of final construction plans, specifications, and associated cost estimates and schedules required to implement construction projects.

d. The accomplishment of facilities siting and other investigations, studies and reports.

A. Master Planning $800,000

Provides for updating, developing and automating existing field installation master plans. This effort includes facility studies, site investigations, and analyses of utility systems. The existing utility and civil drawings will be converted into a highly detailed electronic database using a computer-aided-design (CADD) system. Topographical features from original drawings will be merged electronically to create individual area maps or an entire center map. The master plan documents will be updated to reflect as-built conditions and to graphically represent the 5-year facility plan baseline for future development.

The NASA field center master plans are periodically updated. The master plans are essential as reference documents for land use planning, identification of physical relationships of facilities, and proper orientation and arrangement of facilities. Representative candidates for FY 1994 master planning are as follows:

1. Ames Research Center

An update of the facilities inventory base to include current utilization with emphasis on changes caused by recent facility construction and modifications.

2. Marshall Space Flight Center

An update to reflect as-built condition of facilities and utility systems with emphasis on changes caused by recent facility construction and modifications.

B. Sustaining Engineering Support $1,600,000

Provisions for facility studies and specific engineering support continue in importance as evidenced in recent years. These efforts are important due to changing cost trends in construction materials and fuels; the operation and maintenance costs for the physical plant; and energy conservation and efficiency.

The following items are included in the FY 1994 requirements:

1. Building Research Board

Covers annual support to the Federal Construction Council's (FCC) operations and provides for special studies that the Council will perform throughout FY 1994 to help advance the science and technology of Federal Government building and construction. The FCC is subordinate to the Building Research Board, National Academy of Sciences, and its activities are supported by NASA and other Federal agencies with similar construction programs.

2. Facility Operation and Maintenance Analysis

Provides for studies and engineering support where not otherwise provided for, at NASA field installations relative to functional management of maintenance, automated maintenance management systems, and facilities condition assessments. Included in this activity are field surveys to be conducted at selected NASA field installations to evaluate the effectiveness and efficiency of the operations and maintenance management activities, and to identify possible improvements in productivity.

3. Value Engineering, Cost Validations and Analyses

Provides for engineering services to improve cost-effectiveness of facility projects by subjecting project design criteria, specifications and working drawings for specific material components and systems to detailed independent reviews by engineering specialists. Also provides services necessary to predict and validate facility costs to aid in resources planning.

4. Facilities Utilization Analyses

Provides for the analyses of agencywide facilities utilization data covering (1) office and other types of building space; (2) designate major technical facilities; and (3) special studies comparing the utilization of technical facilities which are similar in type or capability, such as wind tunnels. Such analyses provide for (1) insights into and development of better methods of identifying underutilized facilities; (2) improved techniques to quantify level of facilities use; and (3) actions to improve facilities utilization. Work provides for review of each installation's inventory data base in support of the facilities utilization program. Surveys are necessary to validate the reported data in relation to a specific problem or need, and to assist in providing a credible foundation for plans to improve the use of facilities.

5. Facilities Management Systems

Provides for continued engineering support for the technical updating of NASA's master text construction specifications to reflect the use of new materials, state-of-the-art construction techniques and current references to building codes and safety standards. Also included is the ongoing effort to improve the NASA construction project status reporting and data system.

6. Independent Analysis and Third Party Reviews

Provides the technical and engineering support analyses, designs, and reviews required to verify, confirm and ensure suitability of construction designs within the project cost estimates.

7. Facilities Engineering Metrication

Required to support the transitioning of NASA facilities engineering designs and specifications from the English inch-pound system to metric, as required by Presidential Executive Order 12770 of July 25, 1991.

C. Preliminary Engineering Reports and Related Special Engineering Support $4,000,000

1. Preliminary Engineering Reports (PERs) . . . . . (3,500,000)

This estimate provides for preparation of PERs, investigations, and project studies related to proposed facility projects in the FY 1996 and FY 1997 Construction of Facilities programs. These reports are required to permit the early and timely development of the most suitable project to meet the stated programmatic and functional needs. Reports provide basic data, cost estimates and schedules relating to future budgetary proposals. This request provides for PERs associated with proposed construction.

The estimated cost of PER support for FY 1996 construction projects is $3,000,000, which will permit updating of PERs for $40 to $60 million in construction, and the development of new PERs for an additional $140 to $150 million in projects.

An additional $500,000 has been included in this line for the completion of new PERs for approximately $20 to $30 million of construction projects which will be high priority candidates for inclusion in the FY 1997 Construction of Facilities program. The activity associated with FY 1997 will be confined to the highest priority candidates.

2. Related Special Engineering Support . . . . . (500,000)

This estimate provides for investigations and project studies related to proposed facility projects to be included in the subsequent Construction of Facilities programs. Such studies involve documentation and validation of "as-built" conditions, survey/study of present condition of such items as roofing and cooling towers, utility plant condition and operational modes, and other like studies. These studies are required to allow for the timely development of projects to meet the stated functional needs and to provide basic data, cost estimates and schedules for related future budgetary proposals.

D. Final Design $20,600,000

The amount requested will provide for the preparation of designs, plans, drawings, and specifications necessary for the accomplishment of projects. Projects involved are planned for inclusion in the FY 1995 and FY 1996 programs. The goal is to obtain better facilities on line earlier at a lower cost.

The request will provide for final design work associated with construction proposed for the FY 1995 program, estimated to cost $230 to $250 million, and for $30 to $40 million of high potential projects proposed for the FY 1996 program. The final design amount included for FY 1995 candidates and for residual requirements of this nature which have accumulated from prior years activities is $17,700,000. For FY 1996 $2,900,000 is included and design activity will be confined to the highest priority candidates.

Total . . . . . $27,000,000 CF 16-4

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1994 ESTIMATES

SUMMARY

ENVIRONMENTAL COMPLIANCE AND RESTORATION

Summary of Project Amounts by Location:	Amount	Page No.
Ames Research Center	$2,950,000	CF 17-3
Jet Propulsion Laboratory	2,800,000	CF 17-4
Johnson Space Center	950,000	CF 17-4
Kennedy Space Center	5,500,000	CF 17-5
Langley Research Center	4,910,000	CF 17-6
Lewis Research Center	6,300,000	CF 17-7
Marshall Space Flight Center	2,890,000	CF 17-9
Michoud Assembly Facility	3,000,000	CF 17-10
Stennis Space Center	2,500,000	CF 17-10
Wallops Flight Facility	2,100,000	CF 17-11
White Sands Test Facility	2,230,000	CF 17-11
Various Locations	1,170,000	CF 17-12
Miscellaneous Projects Not in Excess of $250,000 Each	2,750,000	CF 17-12
Remedial Investigations, Feasibility Studies, Assessments, Studies, Design, and Related Engineering	9,950,000	CF 17-12
Total	$50,000,000	

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1994 ESTIMATES

PROJECT TITLE: Environmental Compliance and Restoration Program

INSTALLATION: Various Locations

FY 1994 CoF Estimate: $50,000,000

FY 1992: $36,000,000 FY 1993: $40,000,000

COGNIZANT INSTALLATIONS/LOCATIONS OF PROJECT: Various Locations

COGNIZANT HEADQUARTERS OFFICE: Office of Management Systems and Facilities

SUMMARY PURPOSE AND SCOPE:

These resources will provide for studies, assessments, remedial investigations, feasibility studies, design, related engineering, and remedial action projects for environmental compliance and restoration measures at NASA field installations, Government-owned industrial plants supporting NASA activities, and other locations where NASA operations have contributed to environmental problems and NASA is obligated to contribute to cleanup costs. In addition, these resources will be used to acquire land if necessary to implement environmental compliance and restoration measures. The purpose of this program is to enable NASA to comply with mandatory environmental statutory requirements and standards. The resources authorized and appropriated pursuant to this program may not be applied to other activities. The program includes studies or assessments to determine compliance status and options for remedial action; conduct of prescribed remedial investigations and feasibility studies as required by Federal environmental laws; and performance of environmental restoration, hazardous waste removal and disposal, cleanups, and closures.

PROJECT JUSTIFICATION/DESCRIPTION:

Proposed environmental compliance and restoration projects and activities for Fiscal Year 1994 total $50 million which has been distilled from requests of approximately $75 million. This program represents only a modest request in relation to the total requirements for environmental compliance and restoration that must be implemented within the next several years. Based on relative urgency and potential health hazards, the following listed projects

are the highest priority requirements currently planned for accomplishment in FY 1994. Deferral of these necessary remedial measures would preclude NASA from complying with environmental requirements and jeopardize critical NASA operations. The remedial investigations, feasibility studies, assessments, design, and related engineering costs are estimated to be approximately $9,950,000. Projects estimated to cost less than $250,000 have not been described or identified by specific location. The estimated cost of these projects is $2,750,000. As studies, assessments, remedial investigations, feasibility studies, and designs progress and as new discoveries or regulatory requirements change, it is expected that priorities may change and revisions of the activities and projects may be necessary.

The following listing summarizes broad categories of effort to be undertaken with projects of an estimated cost of over $250,000:

a.	Replacement of Underground Storage Tanks	$5,440,000
b.	Rehabilitation/Replacement of Polychlorinated Biphenyl (PCB) Transformers	860,000
c.	Hazardous Waste Corrective Actions/Cleanups	27,030,000
d.	Hazardous Waste Storage and Control	1,270,000
e.	Oil Spill Prevention and Control	1,500,000
f.	Air and Water Pollution Control	1,200,000

PROJECT COST ESTIMATES:

A. Ames Research Center (ARC) $2,950,000

1. National Full-Scale Aerodynamics Complex Underground Storage Tank Replacement (N221B) 300,000

This project provides for the removal and replacement of an underground storage tank (UST) system and for site remediation adjacent to Building 221B. The single wall UST is located in a contaminated area preventing the effective use of the current vadose zone leak detection system required by UST regulations. The UST system will be removed and replaced with a new double wall tank system with leak detection and monitoring to prevent product releases in conformance with regulatory requirements. The project also includes the removal/treatment of contaminated soil, as needed for construction. The project is required for compliance with the Federal Resource Conservation and Recovery Act (RCRA), state, and local regulations.

2. Remediation of Groundwater Contamination, Middlefield-Ellis-Whisman (MEW) Superfund Site 500,000

This project will continue to provide for NASA's contribution to the remediation of groundwater contamination from the MEW Superfund site. Ames has been designated a potentially responsible party (PRP) by the Environmental Protection Agency (EPA) for the MEW site contamination. The project provides a portion of the funds needed to treat and remove chlorinated solvents, metals, and petroleum hydrocarbon contamination in a groundwater plume currently extending under the Ames site. This project is covered by a Record of Decision (ROD) under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) with the EPA and by state and local regulations.

3. Remediation of Agricultural Site 350,000

This project provides for site remediation of the former agricultural site adjacent to Building N267. The soil and/or groundwater at this site is contaminated with metals, oils, and fuel components released from past practices and aboveground storage tanks and drums previously located at this site. As the extent of the contamination is assessed and evaluated, remedial action alternatives may involve excavation and/or treatment or capping of soil to prevent contaminant migration. The site remediation and closure will comply with Federal and state regulations and standards enforced by the Santa Clara Valley Water District.

4. Fuel System Replacement and Remediation (N211) 1,800,000

This project initiates the work to provide for the removal, replacement and site remediation of the fuel system used by Flight Operations located in Building 211. Leak detection and monitoring, spill containment and site cleanup are required to conform with UST regulatory requirements. This project provides for the removal of existing tanks, piping and

appurtenances; soil and groundwater remediation as needed for construction; and installation of a defueling tank, fueling pits, double-walled supply piping and leak detection system which is fed by a central supply system. The project is required to comply with Federal RCRA, State of California and local regulations.

B. Jet Propulsion Laboratory (JPL) $2,800,000

1. Cleanup of Arroyo Seco Groundwater Contamination 2,000,000

This project provides for continuation of the groundwater cleanup effort of the Arroyo Seco aquifer contamination. Sampling and testing of groundwater in the vicinity of JPL confirmed the presence of trichloroethylene, carbon tetrachloride, and tetrachloroethylene beneath the site and nearby production wells, in excess of Federal and State of California standards. The project provides for ongoing assessments and studies to continue to identify the extent of the contamination and determine remedial alternatives, and for the payment of state oversight costs as required by the Federal Facilities Agreement (FFA). This site is listed in the EPA's "National Priorities List" and therefore is subject to the provisions of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA).

2. Construct Air Pollution Control Units 800,000

This project will initiate the work to provide for the construction of air pollution control devices and installation of emission monitoring systems at JPL-Oak Grove facilities. These control and monitoring devices are required to comply with the emission reduction requirements being incorporated as part of the South Coast Air Quality Management District (SCAQMD) air pollution control regulations. The work involves the addition of emission control devices to equipment in order to control and reduce emission levels and comply with current and pending Federal, state, and local air quality regulations.

C. Johnson Space Center (JSC) $950,000

1. Upgrade Hazardous Waste Storage Facility (358) 950,000

This project provides for modifications to the hazardous waste storage facility and processing areas to reduce waste at the Johnson Space Center and to meet permit standards and provide safe operation of the facility. This project is required to bring JSC into compliance with current regulations regarding hazardous waste storage. The existing storage facility does not meet standards for emergency egress under contingency plan requirements under 40 CFR 264, Subpart C. Other upgrades are required to prevent potential contamination during waste handling and to make more effective use of the area available. This includes the installation of tanks, a lift station, treatment/recovery units and associated equipment.

D. Kennedy Space Center (KSC) $5,500,000

1. Groundwater Remediation, Component Cleaning Facility (CCF) 1,000,000

This project provides for the cleanup and remediation of soil and groundwater contaminants in the area of the CCF lab. Preliminary investigations indicate that the soil and groundwater in the area of CCF have been contaminated with solvents and metals. This project involves soil removal and treatment, groundwater well installations, groundwater treatment system installation, and remediation. This project is required for compliance with the Federal Resource Conservation and Recovery Act (RCRA), state, and local regulations.

2. Groundwater Remediation, Area 55, CCAFS 1,000,000

This project provides for the cleanup and remediation of soil and groundwater contaminants in Area 55, which is located at the Cape Canaveral Air Force Station. Preliminary investigations indicate that the soil and groundwater in Area 55 have been contaminated with solvents. This project provides for soil removal and treatment, groundwater well installations, groundwater treatment system installation, and remediation. This project is required for compliance with RCRA, state, and local regulations.

3. Groundwater Remediation, Launch Complex 36 (LC-36) 1,500,000

This project provides for the cleanup and remediation of soil and groundwater contaminants in LC 36. Preliminary investigations indicate that the soil and groundwater have been contaminated with solvents. This project provides for soil removal and treatment, groundwater well installations, groundwater treatment system installation, and remediation. This project is required for compliance with RCRA, state, and local regulations.

4. PCB/Groundwater Remediation at the Non-Destruct Test Laboratory (NDTL) 1,500,000

This project provides for site remediation of hydrocarbons and photo processing waste contaminants to surface water, soils, and groundwater at the NDTL. In addition, a room within NDTL has been found to be contaminated with polychlorinated biphenyls (PCBs). This project involves the excavation, treatment, removal, and disposal of contaminated soils; installation of groundwater wells and recovery and treatment systems; and the removal, disposal, and replacement of PCB contaminated concrete. This project is required for compliance with RCRA, state, and local regulations.

5. Industrial/LC-39 Areas PCB Transformer Retrofill 500,000

This project will continue the polychlorinated biphenyl (PCB) transformer retrofill in the industrial and Launch Complex 39 (LC-39) areas. This project involves the retrofill of approximately 25 transformers. Upon removal of the PCB containing oil, the transformers will be cleaned, flushed, and refilled with insulating oil which is PCB free. Continued use of the PCB transformers represents a potential hazard to human health and the environment and a significant potential for disruption of the Center's operations and schedules from leaks and/or fires. PCBs are regulated by the Toxic Substance Control Act (TSCA).

E. Langley Research Center (LaRC) $4,910,000

1. Remediation of PCB/PCT at Tabbs Creek 2,000,000

This project provides for continuation of the remediation of Tabbs Creek, contaminated with polychlorinated biphenyls (PCBs) and polychlorinated terphenyls (PCTs). Tabbs Creek is located behind the Center and joins the Northwest Branch of Back River about a mile from the Center property line. Tabbs Creek is a tidal wetland and Back River is used for oyster harvesting. Chemicals were released into the creek from the Langley storm drain system. The Center was cited with a Notice of Violation from the State Water Control Board for the unpermitted discharge of both PCBs and PCTs into Tabbs Creek and Back River, and for the contamination of shellfish in the area. The Center was also cited by the Environmental Protection Agency (EPA) as a noncomplying Federal facility within the Chesapeake Bay watershed. A Federal Facilities Compliance Agreement was signed with the EPA. PCBs are regulated under the Toxic Substances Control Act (TSCA) and cleanup is regulated under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA).

2. Remediation at Stratton Substation 800,000

This project provides for site remediation in and around the Stratton Substation. Sampling and analysis of the soil and groundwater at this site have detected PCB contamination resulting from leakage of PCB containing equipment. Following the definition and evaluation of the extent of the site contamination, remedial action alternatives may involve removal and disposal of contaminated soil and groundwater treatment. PCBs are regulated under the Federal TSCA rules.

3. Replace PCB/PCT Contaminated Air Distribution Piping 350,000

This project provides for the replacement of approximately 4,000 lineal feet of aboveground and underground air distribution piping servicing some buildings in the Langley East Side. A portion of the PCB/PCT contamination encountered in the Langley storm drain system appears to have originated from traps located on the air distribution system piping of buildings served by air compressors lubricated with oil containing PCBs. To eliminate the

source of the contamination, replacement of the contaminated piping is required. PCBs are regulated under TSCA.

4. Removal, Disposal and Replacement of Critical PCB Transformers 360,000

This project provides for the removal and replacement of approximately fourteen polychlorinated biphenyl (PCB) transformers with non-PCB units at various facilities. The project includes the disposal of the replaced units in accordance with environmental regulations. The project will prevent potential contamination and disruption of operations due to leaks, spills, or fires associated with these transformers. The transformers are considered critical to the Center operations. PCBs are regulated under the Toxic Substances Control Act (TSCA).

5. Remedial Investigation/Feasibility Study (RI/FS) for Construction Debris Landfill 1,000,000

This study project provides for performing a Remedial Investigation/Feasibility Study (RI/FS) to investigate the extent and severity of site contamination for site remediation at the Construction Debris Landfill. This land area is marshy and adjacent to tidal wetlands. An initial study identified the presence of suspected drums and oily residues in the soil around the area. This study work includes performing site investigations to fully characterize and assess the site, define the extent of contamination, and to develop and evaluate remedial alternatives for site remediation. The project is required to ensure compliance with requirements under CERCLA.

6. Stormwater Runoff Control and Monitoring 400,000

This project provides for modifications to the Center stormwater drainage system in the East and West Areas. Modifications to the storm drain system are required to control and monitor stormwater runoff discharging from Langley into the Chesapeake Bay in accordance with non-point source pollution regulations under the Clean Water Act. Langley is one of the Federal facilities located within the Chesapeake Bay watershed and a participant in the Chesapeake Bay Initiative.

F. Lewis Research Center (LeRC) $6,300,000

1. Remediation Study/Inspection - Plum Brook Station 1,500,000

This study project will initiate site activities required to verify, assess, and remediate site contamination at the Lewis - Plum Brook Station (PBS), a 6,432 acre site located in Sandusky, Ohio. The facility has been identified by the Environmental Protection Agency (EPA) as requiring site investigations. Solid and hazardous waste contamination may exist from past ordnance work by the Army and research activities by NASA. This initial effort will

include the preparation of project work plans and implementation of a site inspection and related work, leading to development of remedial investigation/feasibility studies (RI/FS) and remediation of identified contaminated areas. This study project will be conducted following the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) guidance.

2. Remediation of Underground Storage Tank Sites, Various Locations 1,500,000

This project provides for continuation of the remediation of soil and/or groundwater from leaking underground storage tank (UST) sites within Lewis and Plum Brook Station (PBS). Site assessments of previously closed UST systems and systems undergoing removal indicate that some of these sites are contaminated with hazardous substances and/or petroleum products. The project includes removal/treatment of contaminants from the soils and groundwater, including performing sampling and analyses to achieve required cleanup levels. Site remediation is required to conform with the Resource Conservation and Recovery Act (RCRA), Federal, and state UST regulations.

3. Remedial Investigation/Feasibility Study (RI/FS) for South and North Central Areas 2,300,000

This study project provides for the performance of Remedial Investigation/ Feasibility Study (RI/FS) for the South and North Central Areas project management units at Lewis. The RI/FS is to be conducted in response to results of a preliminary assessment and site inspection performed under the CERCLA process and the State of Ohio Environmental Protection Agency (OEPA) findings and orders issued to Lewis. The RI/FS will further investigate and assess contamination at prioritized project management units to identify and evaluate treatment options for remediation of these areas.

4. Mercury Cleanup at Buildings 16 and 301 500,000

This project provides for cleanup of mercury contamination in Buildings 16 and 301. Both buildings have control rooms that contained mercury manometer boards, which historically have resulted in breakage and accidental spills of mercury inside buildings. Vacuum research facilities and specific areas within the buildings show evidence of mercury contamination. This project will provide follow-on cleanup at both buildings. The cleanup will require decontamination of equipment and structures to conform with Federal RCRA regulations.

5. Remediation of Building 415 Site 500,000

This project provides for the removal and remediation of contaminated soil at the Building 415 site located in the West Area. The building was previously used for rocket fuel testing and storage and dispensing of chemicals and hazardous wastes. Preliminary assessment documentation indicates hazardous and petroleum contaminants may exist from these past activities. The work involves the removal/treatment of soil and/or groundwater contaminants

based on the results of scheduled investigations during building closure. Cleanup is required to conform with RCRA regulatory requirements.

G. Marshall Space Flight Center (MSFC) $2,890,000

1. RCRA Facility Investigation (RFI) 1,000,000

This project provides the work required for assessment, investigation, and cleanup of sites with potential contamination as identified in the Preliminary Assessment (PA) by the Environmental Protection Agency (EPA) and MSFC. The PA indicates a potential for contamination of soil and groundwater resulting from past practices associated with the operations of the Center.

2. Cleanup of Groundwater Contamination, Santa Susana Field Laboratory (SSFL) 500,000

This project is a continuation of the assessment/cleanup and characterization of the groundwater and hydrogeological regime currently under way at SSFL. The assessment/cleanup will consist of well installations, report preparation, and capital purchases. Current results indicate a high level of trichloroethylene in the groundwater, which has been associated with rocket engine testing performed at SSFL by both NASA and the Air Force. This project is required to be in compliance with the Resource Conservation and Recovery Act (RCRA) and with the regulations of the state of California.

3. Cleanup of Solid Waste Management Units (SWMU), SSFL 400,000

This project will provide for the characterization, assessment, and remediation of the most critical of the SWMUs identified by SSFL, the Environmental Protection Agency (EPA), and the state of California. The SWMUs involved in this cleanup include NASA's Area II SWMUs and sites associated with rocket engine testing on Rocketdyne's Areas I and III. This project will involve the installation of treatment units and a wide array of assessment methodologies including soil borings, well installations, sampling, and soil removal.

4. Remove and Replace Underground Storage Tanks, Various Locations 990,000

This project continues a program to replace the underground storage tanks (UST) at MSFC. This project will remove and replace ten USTs with an aboveground system that will provide equivalent capabilities. These tanks must be replaced to comply with Federal and state of Alabama regulations.

H. Michoud Assembly Facility (MAF) $3,000,000

1. Modify Aboveground Storage Tanks, Facility Wide 1,000,000

This project continues the program to upgrade and modify aboveground chemical and petroleum product/waste tanks located throughout the facility. The work includes overfill alarms, secondary containment, visual-level indicators, dry disconnects, and emission controls needed to comply with Federal and state of Louisiana regulations.

2. Groundwater Remediation Activities 2,000,000

This project is a continuation of the remediation activities associated with the Solid Waste Management Units (SWMU) identified during the Resource Conservation and Recovery Act (RCRA) facility investigation. The work includes well installation and contaminated soil/material removal and disposal. This project is required by MAF's RCRA permit.

I. Stennis Space Center (SSC) $2,500,000

1. Remediation of Herbicide/Pesticide Area 1,300,000

This project provides for the remediation of contaminated soil and groundwater associated with SSC herbicide/pesticide handling facility. Work will include well installation, contaminated material removal and disposal, and backfill of any excavated areas. The project is required to be in compliance with Federal and state of Mississippi regulations.

2. Replace Aboveground Storage Tanks 500,000

This project provides for the replacement in one kind of one 100,000 gallon aboveground tank and the replacement of two 65,000 gallon tanks with one 100,000 gallon aboveground tank.. Work will include installation of associated piping, spill prevention devices, and the disposal of the old tanks and any contaminated soil. This work is required to bring SSC into compliance with Federal and state of Mississippi regulations.

3. RCRA Facility Investigation (RFI) 700,000

This project provides the work required for assessment, investigation, and removal actions at sites with potential contamination as identified in the Site Inspection (SI). The SI indicates a potential for contamination of soil and groundwater resulting from past practices associated with the operations of the Center.

J. Wallops Flight Facility (WFF) $2,100,000

1. Removal of PCB Contaminated Soil, Scrapyard and Transformer Area . . . 1,100,000

This project provides for the removal and disposal of soil in the scrapyard and transformer pad areas which have been contaminated with polychlorinated biphenyls (PCBs) and mercury. The contamination was identified in the Preliminary Assessment required by the Environmental Protection Agency. This project is governed by the Toxic Substance Control Act (TSCA) and state of Virginia regulations.

2. Fire Training Area Remediation 1,000,000

This project provides for the removal and disposal of soil and for the treatment and remediation of groundwater contaminated with volatile and semi-volatile organics. The work will include installation of groundwater wells and treatment units and groundwater sampling and analysis. This project is required by Federal and state of Virginia regulations.

K. White Sands Test Facility (WSTF) $2,230,000

1. Groundwater Contamination Assessment and Remediation 2,000,000

This project is the continuation of the ongoing groundwater assessment at WSTF. This project provides for the quantification, definition, and assessment of the impacts and the remedial alternatives available to WSTF. The project will also provide the RCRA Facility Investigation (RFI) and the Corrective Measures Study (CMS) reports as required by a RCRA 3008(h) consent order.

2. Contamination Assessment, Property Acquisition 230,000

This project provides for the purchase of three parcels of privately owned land totaling approximately 210 acres located roughly 2.5 miles southwest of the WSTF boundary. The groundwater assessment that WSTF has been conducting has confirmed that groundwater contaminated with trichloroethylene (TCE) and freon has migrated in a southwesterly direction and is located adjacent to the private land. The purchase of the three parcels is necessary as groundwater well installation and assessment on the private land is now required. Acquisition of the private land will also provide NASA with a buffer zone and eliminate the possibility of development and drinking water well installation thereby reducing the potential of endangerment to human health.

L. Various Locations $1,170,000

1. Replace Underground Storage Tanks, Madrid, Spain 850,000

This project initiates the work for the replacement and upgrade of underground storage tank (UST) systems at the Madrid Deep Space Communications Complex (MDSCC). The USTs at the MDSCC consist of single wall steel tanks used for the storage of petroleum products and hazardous substances. This work involves the removal, replacement and upgrade of UST systems to provide for secondary containment, leak detection, and monitoring to prevent future releases. The project also includes the removal/disposal of contaminated soil and repair of surface areas. The UST system modifications will be in conformance with requirements under the Federal Resource Conservation and Recovery Act (RCRA) and local regulations.

2. Upgrade Hazardous Materials and Waste Storage Areas, Canberra, Australia 320,000

This project provides for construction of an open-sided hazardous materials/waste storage shed and for removal, treatment, and disposal of contaminated soil at the Canberra Deep Space Communications Complex (CDSCC). The new roofed, open-sided storage shed will provide for the storage of hazardous materials and wastes and will be equipped with fire, safety, and ancillary equipment in accordance with environmental regulations. The project will also include the removal, treatment, and disposal of contaminated soils. The work is necessary for compliance with both local and U.S. environmental regulations.

M. Miscellaneous Projects Not in Excess of $250,000 Each $2,750,000

N. Remedial Investigations, Feasibility Studies, Assessments, Studies, Design, and Related Engineering $9,950,000

Total $50,000,000

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

Approximately $55-60 million per year for the next few years is the current estimate for meeting Environmental Compliance and Restoration requirements. This figure will become better defined as studies are completed and remediation projects are reviewed by Federal, state, and local regulators.

FISCAL YEAR
1994

BUDGET ESTIMATES

VOLUME III

RESEARCH
&
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MANAGEMENT

SPECIAL ANALYSES

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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VOLUME III

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RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1994 ESTIMATES

GENERAL STATEMENT

The Research and Program Management (R&PM) appropriation provides the salaries, other personnel and related costs and travel support for NASA's civil service workforce.

This civil service workforce is the underpinning for the successful accomplishment of the Nation's civil aeronautics and space programs. These are the people who plan the programs; conduct and oversee the research; select and monitor the contractors; manage the various research, development, and test activities; and oversee all of NASA's operations. The salaries and benefits of this workforce comprise approximately 95 percent of the requested appropriation. The remaining 5 percent of the requested appropriation is required to fund travel necessary to manage NASA and its programs, and provide the training and other supporting costs for NASA personnel.

This FY 1994 budget funds costs associated with 23,623 Full-Time Equivalent (FTE) workyears. This reflects a reduction of 608 FTE consistent with Presidential Executive Order 12839 "Reductions of 100,000 Federal Positions". In spite of the staff reductions (which will occur through attrition), the FY 1994 budget represents a 3.7 percent dollar increase over FY 1993. This increase will allow for the following: full-year funding of the civilian pay and benefit increases granted in January 1993, maintenance of training and travel at FY 1992 levels, full-year funding for promotions, within-grade increases and other personnel actions, and provision for lump sum annual leave payments due to anticipated retirements from the Senior Executive Service (SES) workforce in FY 1994. There is no pay raise budgeted in FY 1994.

NASA Field Centers report to the various Program Associate Administrators responsible for the major portion of their technical programs. The FY 1994 FTE distribution by program reflects the recent reorganization of the Office of Space Science. With the exception of the Space Station program, which is currently under review, the principal roles assigned to each Installation, based on demonstrated capabilities and capacities to meet NASA's overall program goals, are described below:

OFFICE OF SPACE FLIGHT:

Johnson Space Center (JSC) - Management, selection, and training of astronauts and mission specialists, and Shuttle Flight operations, including mission planning, operational procedures, and flight control.

Kennedy Space Center (KSC) - Management of Shuttle Launch Operations, including orbiter processing, final payload checkout and integration with the Shuttle, Shuttle launch, and post landing processing.

Marshall Space Flight Center (MSFC) - Management of the Space Shuttle Main Engine, Solid Rocket Booster, and External Tank projects; management of NASA's activities on the Spacelab project; and development and conducting of experiments in materials processing in space.

Stennis Space Center (SSC) - Space Shuttle engine testing, and Earth resources research and technology transfer.

OFFICE OF MISSION TO PLANET EARTH:

Goddard Space Flight Center (GSFC) - Development and operation of Earth orbital flight experiments and automated spacecraft to conduct scientific investigations and to demonstrate practical applications; management of tracking and data acquisition activities; management and launch of sounding rockets and balloons; operation of an instrumented flight range for aeronautical and space research and procurement of expendable launch services for small and medium payloads. The Goddard Space Flight Center has also begun development of the Earth Observing Systems (EOS) and its associated data system. The Wallops Flight Facility is an operational element and component installation of the Goddard Space Flight Center.

OFFICE OF AERONAUTICAL RESEARCH AND TECHNOLOGY:

Ames Research Center (ARC) - Conduct of activities involving computational aerodynamics and flight testing, computational/numerical simulation rotorcraft technology; short and vertical takeoff and landing technology; life sciences dealing with gravitational biology, and exobiology; human factors; autonomous systems; guidance and control; and operation of an alternate landing site for the Space Shuttle missions. The Dryden Flight Research Facility is an operational element and component installation of the Ames Research Center.

Langley Research Center (LaRC) - Conduct of airframe aerodynamics and structures research and technology; hypersonic propulsion; experimental and theoretical aerodynamics; environmental quality monitoring by remote sensing; advanced conceptual space system design independent assessments; research in the areas of structures and materials, guidance and controls; and airframe/propulsion integration of the transatmospheric research and technology program.

Lewis Research Center (LeRC) - Conduct of aeronautical propulsion, nuclear space propulsion, electric space propulsion, and space power research and technology; space communications research and technology; development of microgravity sciences for fluid physics and combustion science; and procurement of expendable launch services on intermediate and large payload vehicles.

NASA HEADQUARTERS (HQ) - Overall executive direction of NASA's programs and activities, including functional management of such areas as personnel policies and development, Equal Employment Opportunity, procurement, financial management, information resource management, logistics, etc.

SUMMARY OF FUNDING REQUIREMENTS

The FY 1994 Budget provides the necessary resources to apply in-house capabilities to program activities. Detailed data on funding requirements are provided in the section on each Installation. A summary description of, and the funding required by the functional category includes:

I. Personnel and Related Costs ($1,623,536,000): Includes salaries and benefits, the Government's contribution to personnel benefits for NASA civil service employees, and for personnel of other Government agencies detailed to NASA. In FY 1994, the budget provides for 23,623 FTE workyears exclusive of the Inspector General. This category also includes other personnel and related costs such as, moving expenses (excluding the associated travel of people); recruiting and personnel investigation services provided by the Office of Personnel Management; and the training of NASA civil service employees.

II. Travel ($51,464,000): Includes the cost of transportation, per diem, and related travel expenses--domestic and foreign--of civil service employees who travel for coordination and management of NASA program activities including contract management; flight mission support; meetings and technical seminars and symposia; and for permanent and temporary relocations.

SUMMARY OF THE BUDGET PLAN BY FUNCTION

		1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)			
I.	Personnel and Related Costs	1,526,715	1,604,535	1,568,375	1,623,536
II.	Travel	49,141	55,492	46,639	51,464
	Total, NASA	1,575,856	1,660,027	1,615,014	1,675,000

SUMMARY OF CHANGES FROM THE FY 1993 BUDGET TO THE FY 1993 CURRENT ESTIMATE

The FY 1993 budget request of $1,660.0 million is revised to $1,615.0 million. The current R&PM plan includes the following changes:

FY 1993 Budget Request.....	$1,660.0
Congressional Action:	- 45.0
Project Core	- 26.0
Travel	- 2.0
General	- 17.0
FY 1993 Current Estimate.....	$1,615.0

BASIS OF THE FY 1994 ESTIMATE

The FY 1994 Budget Estimate of $1,675.0 million represents an increase of $60.0 million over the current FY 1993 R&PM plan. This increase provides for a civil service ceiling of 23,623 workyears, the full year cost of the FY 1993 pay raise, and travel consistent with increased transportation and related costs and program requirements.

The appropriation request for FY 1994, by functional category, is summarized below:

I. Personnel and Related Costs ($1,623,536,000): The FY 1994 estimate for Personnel and Related Costs is $55.1 million higher than FY 1993. Of the increase: $15.3 million is for employee benefits, to include the rising costs of health care and the increased share of government payments to the Federal Employees Retirement System; $15.3 million is for the full year cost of the FY 1993 pay raise; $15.8 million is for normal personnel actions such as promotions, within grade increases, and military detailees; and the remaining $8.7 million is for training and other support services. Included in the above is funding for anticipated annual leave lump sum payments due to anticipated retirements from the SES workforce in January 1994.

II. Travel ($51,464,000): NASA relies very heavily on contracts with the private sector for the actual accomplishment of its programs and providing responsible oversight of these contractors requires considerable travel to the contractor locations. Additionally, the launch of a major payload on the Space Transportation System involves the integration and coordination of a very large number of people and activities. This can only be effectively accomplished by holding multiple pre-launch meetings in multiple locations. In total, program travel is approximately two-thirds of NASA's travel expenditures. The remaining travel funds are required to coordinate Agency management and administration, for professional development and training, and for the transportation of new and transferred employees to new duty stations. The FY 1994 increase in travel is intended to respond to increased travel costs and program and project management, and supervision.

In summary, the FY 1994 budget requirement of $1,675,000,000 is to provide for 23,623 FTE civil service workyears to support the activities at eight NASA Installations and Headquarters, consistent with the Research and Development; Space Flight, Control and Data Communications; and Construction of Facilities program plans.

DETAIL OF CONTENTS BY FUNCTION

I. Personnel and Related Costs

A. Compensation and Benefits:

1. Compensation:

a. Permanent Positions: This part of Personnel and Related Costs covers the salaries of the full-time permanent civil service workforce and is the largest portion of this functional category.

b. Other Than Full-Time Permanent Positions: This category includes the salaries of NASA's non-permanent workforce. Programs such as Presidential Management Interns, students participating in cooperative training, summer employment, youth opportunity, and temporary clerical support are covered in this category.

c. Reimbursable Detailees: In accordance with existing agreements, NASA reimburses the parent Federal organization for the salaries and related costs of persons detailed to NASA.

d. Overtime and Other Compensation: Overtime, holiday, post and night differential, and hazardous duty pay are included in this category. Also included are incentive awards for outstanding achievement and superior performance.

2. Benefits: In addition to compensation, NASA, as authorized and required by law, makes the employer's contribution to personnel benefits. These benefits include contributions to the Civil Service Retirement Fund, the Federal Employees Retirement System, employees' life and health insurance, payments to the Medicare fund for permanent employees, and social security contributions. Payments to the civil service retirement fund for re-employed annuitants and severance pay to former employees involuntarily separated through no fault of their own are also included.

B. Supporting Costs:

1. Transfer of Personnel: Provided under this category are relocation costs required by law, such as the expenses of selling and buying a home, subsistence expenses, and the movement and storage of household goods.

2. Investigative Services: The Office of Personnel Management is reimbursed for activities such as security investigations of new hires and revalidation of sensitive position clearances, recruitment advertising, and Federal wage system surveys.

3. Personnel Training: Training is provided within the framework of the Government Employees Training Act of 1958. Part of the training costs are for courses offered by other Government agencies, and the remainder is for training through nongovernment sources.

II. Travel

A. Program Travel: The largest part of travel is for direction, coordination, and management of program activities including international programs and activities. The complexity of the programs and the geographical distribution of NASA Installations and contractors necessitate this category of travel. As projects reach the flight stage, support is required for prelaunch activities including overseas travel to launch and tracking sites. The amount of travel required for flight projects is significant as it is directly related to the number of systems and subsystems, the number of design reviews, and the number and complexity of the launches and associated ground operations.

B. Scientific and Technical Development Travel: Travel to scientific and technical meetings and seminars permits employees engsged in research and development to participate in both Government sponsored and nongovernment sponsored activities. This participation allows personnel to benefit from exposure to technological advances which arise outside NASA, as well as allowing personnel to present both accomplishments and problems to their associates and provides for the dissemination of technical results to the United States community.

C. Management and Operations Travel: Management and operations travel provides for the direction and coordination of general management matters and travel by officials to

review the status of programs. It also includes travel by functional managers in such areas as personnel, financial management, and procurement. This category also includes the cost of travel of unpaid members of research advisory committees; and initial duty station, permanent change of assignment, and related travel expenses.

CENTER LOCATIONS AND CAPITAL INVESTMENT

JOHNSON SPACE CENTER - The Lyndon B. Johnson Space Center is located 20 miles southeast of Houston, Texas. NASA owns 1618 acres of land at the Houston site and uses another 60,552 at the White Sands Test Facility, Las Cruces, New Mexico. The total capital investment including land, buildings, structures and facilities, equipment, and other fixed assets was $1,112,140,000 as of September 30, 1992.

KENNEDY SPACE CENTER - The Kennedy Space Center is located 50 miles east of Orlando, Florida. NASA owns 82,943 acres and uses facilities at Cape Canaveral Air Station and Vandenberg Air Force Base. The total capital investment including land, buildings, structures and facilities, equipment, and other fixed assets was $2,159,222,000 as of September 30, 1992.

MARSHALL SPACE FLIGHT CENTER - The Marshall Space Flight Center is located within the U.S. Army's Redstone Arsenal at Huntsville, Alabama. MSFC also manages operation at the Michoud Assembly 15 miles east of New Orleans, Louisiana and the Slidell Computer Complex in Slidell, Louisiana. The total capital investment including land, buildings, structures and facilities, equipment, and other fixed assets was $1,345,890,000 as of September 30, 1992.

STENNIS SPACE CENTER - The Stennis Space Center is located approximately 50 miles northeast of New Orleans, Louisiana. NASA owns 20,588 acres and has easements covering an additional 118,284 acres. The total capital investment including land, buildings, structures and facilities, equipment, and other fixed assets was $439,092,000 as of September 30, 1992.

GODDARD SPACE FLIGHT CENTER - The Goddard Space Flight Center is located 15 miles northeast of Washington, D.C. at Greenbelt, Maryland. NASA owns 1,106 acres at this location and an additional 6,176 acres at the Wallops Flight Facility in Wallops Island, Virginia. The total capital investment including land, buildings, structures and facilities, equipment, and other fixed assets at both locations was $1,042,910,000 as of September 30, 1992.

AMES RESEARCH CENTER - The Ames Research Center is located south of San Francisco on Moffett Field, California, and operates the Ames Dryden Flight Research Facility located 65 miles northeast of Los Angeles at Edwards Air Force Base. NASA owns 429.9 acres at the Moffett Field location. The total capital investment including land, buildings, structures and facilities, equipment, and other fixed assets at both locations was $1,265,256,000 as of September 30, 1992.

LANGLEY RESEARCH CENTER - The Langley Research Center is adjacent to Langley Air Force Base which is located between Williamsburg and Norfolk at Hampton, Virginia. NASA owns 807 acres and has access to 3,276 acres. The total capital investment including land, buildings, structures and facilities, equipment, and other fixed assets was $1,014,039,000 as of September 30, 1992.

LEWIS RESEARCH CENTER - The Lewis Research Center occupies two sites; the main site is in Cleveland, Ohio, adjacent to Cleveland-Hopkins Airport; the second site is the Plum Brook Station located south of Sandusky, Ohio, and 50 miles west of Cleveland. NASA owns 6,820 acres and leases an additional 14 acres at the Cleveland location. The total capital investment including land, buildings, structures and facilities, equipment, and other fixed assets at both locations was $710,014,000 as September 30, 1992.

NASA HEADQUARTERS - NASA Headquarters is located at Two Independence Square, 300 E St. SW, Washington, DC and occupies other buildings in the District of Columbia, Maryland, and Virginia.

DISTRIBUTION OF FULL TIME EQUIVALENT WORKYEARS BY INSTALLATION

	1992 ACTUAL	1993 BUDGET ESTIMATE	1993 CURRENT ESTIMATE	1994 BUDGET ESTIMATE
JOHNSON SPACE CENTER	3,640	3,631	3,606	3,548
KENNEDY SPACE CENTER	2,543	2,510	2,508	2,467
MARSHALL SPACE FLIGHT CENTER	3,735	3,650	3,660	3,560
STENNIS SPACE CENTER	221	216	213	211
GODDARD SPACE FLIGHT CENTER	3,988	3,985	3,954	3,894
AMES RESEARCH CENTER	2,256	2,225	2,211	2,185
LANGLEY RESEARCH CENTER	2,946	2,925	2,914	2,869
LEWIS RESEARCH CENTER	2,799	2,787	2,757	2,725
HEADQUARTERS	1,932	2,006	1,934	1,924
SUBTOTAL, FULL–TIME PERMAMENT WORKYEARS	24,060	23,935	23,757	23,383
OTHER THAN FULL–TIME PERMAMENT WORKYEARS	270	296	232	240
SUBTOTAL, CEILING CONTROLLED FTE	24,330	24,231	23,989	23,623
CORE		500	0	0
GRAND TOTAL, CEILING CONTROLLED FTE	24,330	24,731	23,989	23,623

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SUMMARY OF BUDGET PLAN BY INSTALLATION
(THOUSANDS OF DOLLARS)

	1992 ACTUAL	1993 BUDGET ESTIMATE	1993 CURRENT ESTIMATE	1994 BUDGET ESTIMATE
JOHNSON SPACE CENTER	245,944	255,441	252,475	261,086
KENNEDY SPACE CENTER	155,464	164,413	163,039	168,557
MARSHALL SPACE FLIGHT CENTER	231,657	237,137	234,730	242,847
STENNIS SPACE CENTER	14,264	16,322	14,643	15,279
GODDARD SPACE FLIGHT CENTER	249,989	264,580	257,846	266,311
AMES RESEARCH CENTER	158,860	172,228	162,876	169,529
LANGLEY RESEARCH CENTER	172,851	179,665	179,601	186,617
LEWIS RESEARCH CENTER	172,326	183,138	178,334	185,769
HEADQUARTERS	174,501	187,103	171,470	179,005
TOTAL, RESEARCH AND PROGRAM MANAGEMENT	1,575,856	1,660,027	1,615,014	1,675,000

DISTRIBUTION OF FULL-TIME EQUIVALENT (FTE) WORKYEARS BY PROGRAM

NASA TOTAL

	FY 1992 ACTUAL	FY 1993 BUDGET ESTIMATE	FY 1993 CURRENT ESTIMATE	FY 1994 BUDGET ESTIMATE
SPACE STATION AND NEW TECHNOLOGY INVESTMENTS	2,261	2,370	2,640	2,640 *
SPACE FLIGHT PROGRAMS	5,764	5,679	5,258	5,036
SPACE TRANSPORTATION CAPABILITY DEVELOPMENT	1,733	1,600	1,548	1,443
SPACE SHUTTLE PRODUCTION AND OPERATIONS	4,031	4,079	3,710	3,593
LAUNCH SERVICES	249	0	237	181
SPACE SCIENCE	2,370	2,404	2,466	2,196
PHYSICS AND ASTRONOMY	2,157	2,175	2,258	1,968
PLANETARY EXPLORATION	213	229	208	228
LIFE SCIENCES/	326	324	315	0
LIFE AND MICROGRAVITY SCIENCES	0	0	0	1,055
SPACE APPLICATIONS/	1,822	1,952	1,940	0
MISSION TO PLANET EARTH	0	0	0	1,549
ADVANCED CONCEPTS AND TECHNOLOGY	1,766	1,885	1,605	1,568
SPACE RESEARCH AND TECHNOLOGY	1,603	1,724	1,446	1,404
COMMERCIAL PROGRAMS	163	161	159	164
AERONAUTICAL RESEARCH AND TECHNOLOGY	3,289	3,271	3,366	3,428
TRANSATMOSPHERIC RESEARCH AND TECHNOLOGY	135	108	100	68
SPACE EXPLORATION	179	105	74	0
SAFETY RELIABILITY AND QUALITY ASSURANCE	125	141	129	132
ACADEMIC PROGRAMS	27	26	35	35
TRACKING AND DATA PROGRAMS	709	713	695	675
SUBTOTAL DIRECT	19,022	18,978	18,860	18,563
CENTER MANAGEMENT AND OPERATIONS	5,038	4,957	4,897	4,820
SUBTOTAL (FULL-TIME PERMANENT)	24,060	23,935	23,757	23,383
OTHER CONTROLLED FTE'S	270	296	232	240
TOTAL, FULL-TIME EQUIVALENTS	24,330	24,231	23,989	23,623
CORE	0	500	0	0
TOTAL, PROGRAM PLAN	24,330	24,731	23,989	23,623

*UNDER REVIEW

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
RESEARCH AND PROGRAM MANAGEMENT – FY 1994 ESTIMATES
DISTRIBUTION OF BUDGET PLAN BY FUNCTION BY INSTALLATION

FUNCTION	TOTAL NASA	JOHNSON SPACE CENTER	KENNEDY SPACE CENTER	MARSHALL SPACE FLIGHT CENTER	STENNIS SPACE CENTER	GODDARD SPACE FLIGHT CENTER	AMES RESEARCH CENTER	LANGLEY RESEARCH CENTER	LEWIS RESEARCH CENTER	HEADQUARTERS
PERSONNEL AND RELATED COSTS										
1992 ACTUAL	1,526,715	239,253	151,872	225,463	13,688	242,933	154,023	168,170	167,945	163,368
1993 BUDGET	1,604,535	246,105	159,687	230,002	15,641	256,800	166,900	174,500	176,400	174,500
1993 CURRENT	1,568,375	246,236	158,915	228,622	14,096	250,748	158,935	175,709	174,332	160,784
1994 BUDGET	1,623,536	254,597	164,130	236,496	14,710	259,247	164,332	181,617	181,068	167,319
TRAVEL										
1992 ACTUAL	49,141	6,691	3,592	8,194	576	7,056	4,837	4,681	4,381	11,133
1993 BUDGET	55,492	7,336	4,726	7,135	681	7,760	5,328	5,165	4,738	12,603
1993 CURRENT	46,639	6,239	4,124	6,108	547	7,100	3,941	3,892	4,002	10,686
1994 BUDGET	51,464	6,489	4,427	6,351	569	7,064	5,197	5,000	4,681	11,686
TOTAL										
1992 ACTUAL	1,575,856	245,944	155,464	231,657	14,264	249,989	158,860	172,851	172,326	174,501
1993 BUDGET	1,660,027	255,441	164,413	237,137	16,322	264,560	172,228	179,665	183,138	187,103
1993 CURRENT	1,615,014	252,475	163,039	234,730	14,643	257,646	162,876	179,601	176,334	171,470
1994 BUDGET	1,675,000	261,086	168,557	242,847	15,279	266,311	169,529	186,617	185,769	179,005

PROPOSED APPROPRIATION LANGUAGE

RESEARCH AND PROGRAM MANAGEMENT

For necessary expenses for personnel and related costs, including uniforms or allowances therefor, as authorized by law (5 U.S.C. 5901-5902) and travel expenses, [$1,615,014,000] *$1,675,000,000: Provided,* That contracts may be entered into under this appropriation for training, investigations, costs associated with personnel relocation, and for other services, to be provided during the next fiscal year *(Departments of Veterans Affairs and Housing and Urban Development, and Independent Agencies Appropriations Act, 1993.)*

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1994 ESTIMATES

LYNDON B. JOHNSON SPACE CENTER

CENTER ROLES AND MISSIONS

PRINCIPAL ROLES:

Space Station - Currently under review.

Space Shuttle Production and Operations Capability - Modification of the orbiters; equipment upgrades to facilities; configuration management; system engineering and integration; and development, scheduling, and acquisition and/or modifications of support aircraft for astronaut training and flight operations.

Space Shuttle Operations - Operations planning, crew selection and training, medical operations, orbiter and payload flight control, utilization planning, and payload accommodation studies.

Environmental Effects and Crew Support Systems - Management, development, and analysis of the data base to ascertain any environmental impact of Space Transportation System (STS) operations. Development and demonstration of Environmental Control and Life Support Systems (ECLSS) and Extravehicular Activity (EVA) systems suitable for STS and advanced needs.

Advanced Missions and Technology - Management of studies to define advanced transportation and orbital systems. Development of prototypes, new systems and software for advanced systems.

Spacelab Development - Crew training in conjunction with flight hardware, and development and operation of simulators.

Payload Integration and Operations - Provides optional services for NASA payloads other than standard Shuttle services including development and delivery of payload accommodation equipment for capabilities common to multiple NASA missions.

Manned Vehicles - Development of manned space vehicles and associated supporting technology.

Life Science - Performance of medical research, investigation and development of solutions to space medicine problems, and development of information systems and equipment in support of medical operations and experiments; development of nutritional requirements and food preparation and packaging systems; development of Spacelab life sciences research capability; and definition and development of in-flight biomedical experiments.

SUPPORTING ROLES:

Lunar and Planetary Geosciences - Development and maintenance of technical discipline base for lunar and planetary geosciences and planetary material handling techniques.

Technology Experiments in Space - Management of the Orbiter experiments.

DISTRIBUTION OF FULL-TIME EQUIVALENT (FTE) WORKYEARS BY PROGRAM

JOHNSON	FY 1992 ACTUAL	FY 1993 BUDGET ESTIMATE	FY 1993 CURRENT ESTIMATE	FY 1994 BUDGET ESTIMATE
SPACE STATION AND NEW TECHNOLOGY INVESTMENTS	793	826	929	929 *
SPACE FLIGHT PROGRAMS	1,914	1,905	1,906	1,880
SPACE TRANSPORTATION CAPABILITY DEVELOPMENT	507	511	579	571
SPACE SHUTTLE PRODUCTION AND OPERATIONS	1,407	1,394	1,327	1,309
LAUNCH SERVICES	0	0	0	0
SPACE SCIENCE	45	46	49	24
PHYSICS AND ASTRONOMY	18	13	25	0
PLANETARY EXPLORATION	27	33	24	24
LIFE SCIENCES/	92	91	93	0
LIFE AND MICROGRAVITY SCIENCES	0	0	0	125
SPACE APPLICATIONS/	2	4	3	0
MISSION TO PLANET EARTH	0	0	0	0
ADVANCED CONCEPTS AND TECHNOLOGY	81	91	51	50
SPACE RESEARCH AND TECHNOLOGY	49	75	33	30
COMMERCIAL PROGRAMS	12	16	18	20
AERONAUTICAL RESEARCH AND TECHNOLOGY	0	0	0	0
TRANSATMOSPHERIC RESEARCH AND TECHNOLOGY	0	0	0	0
SPACE EXPLORATION	117	83	28	0
SAFETY RELIABILITY AND QUALITY ASSURANCE	0	0	0	0
ACADEMIC PROGRAMS	0	0	0	0
TRACKING AND DATA PROGRAMS	0	0	0	0
SUBTOTAL DIRECT	3,024	3,046	3,059	3,008
CENTER MANAGEMENT AND OPERATIONS	616	585	547	540
SUBTOTAL (FULL-TIME PERMANENT)	3,640	3,631	3,606	3,548
OTHER CONTROLLED FTE'S	32	34	22	25
TOTAL, FULL-TIME EQUIVALENTS	3,672	3,665	3,628	3,573
CORE	0	20	0	0
TOTAL, PROGRAM PLAN	3,672	3,685	3,628	3,573

*UNDER REVIEW

PROGRAM DESCRIPTION

	Permanent Civil Service Workyears
SPACE STATION AND NEW TECHNOLOGY INVESTMENTS.....	929

Currently under review.

SPACE FLIGHT PROGRAMS.....	1,880
SPACE TRANSPORTATION CAPABILITY DEVELOPMENT.....	571

This activity includes Center support to Spacelab, the engineering technical base, payload operations and support equipment, and advanced programs. Payload operations activities provide optional services for NASA payloads. The Engineering and Technical Base (ETB) provides the base research and engineering capability necessary to support ongoing and future efforts. Advanced programs conducts concept studies and development on flight systems and options for human transportation.

SPACE SHUTTLE PRODUCTION AND OPERATIONS.....	1,309

The staffing provides for Shuttle activities to support a schedule consistent with the major program milestones. It also provides development, integration, and operations support for the Mission Control Center (MCC), the Shuttle Mission Simulator (SMS), and other ground facilities needed for Space Shuttle operations. The staffing provides for Shuttle operational flight program management including system integration crew, equipment modification and processing, crew training, flight mission planning and operations, and procurement of Orbiter hardware.

	Permanent Civil Service Workyears
SPACE SCIENCE	24
PLANETARY EXPLORATION	24

The Center supports the Agency's planetary science program in the area of geosciences required to support potential future programs, provide curatorial support for lunar materials, assist in information dissemination, and interact with outside scientists. The research focuses on the composition, structures, and evolutionary histories of the solid bodies of the universe.

LIFE AND MICROGRAVITY SCIENCES	125

The Center has the lead role in evaluating human physiological changes associated with the space flight environment and developing effective countermeasures to assure crew health and optimal performance during all phases of flight. Other operationally oriented medical activities include defining and developing on-board health care systems and environmental monitoring systems; crew medical training; ground-based medical support of missions; developing a longitudinal crew health data base; and developing medical and psychological crew selection criteria. JSC has established a center for the support of biotechnology applications in microgravity in order to study growth factors, medical chemo/immunotherapeutics, and human tissue transplantation.

ADVANCED CONCEPTS AND TECHNOLOGY	50
SPACE RESEARCH AND TECHNOLOGY	30

JSC provides technology to support the evolution of the Space Shuttle, and the development of transportation systems for planetary exploration.

	Permanent Civil Service Workyears
COMMERCIAL PROGRAM.....	20

This program's two primary goals are to promote and develop private sector investment in space-base technologies and to promote industrial productivity through the transfer to the nation's commercial sector of technologies that derive from NASA's Research and Development (R&D) programs and activities. To achieve its goals, Commercial Programs works to establish innovative partnerships and innovative approaches leading to new commercial enterprises, products, and services.

CENTER MANAGEMENT AND OPERATIONS SUPPORT.....	540

Center Management and Operations Support provides services to all JSC organizations. The civil service personnel include:

Director and Staff - The Center Director, Deputy Director, and immediate staff, e.g, Legal, Personnel, Equal Opportunity, Technical Planning, and Public Affairs.

Management Support - Personnel providing information and control service supporting all levels of Center management, both program and functional.

Operations Support - Personnel managing and providing for the operation and maintenance of institutional facilities, buildings, systems, and equipment.

		1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)			
I.	PERSONNEL AND RELATED COSTS	239,253	248,105	246,236	254,597
A.	COMPENSATION AND BENEFITS	234,475	242,213	243,256	251,213
1.	COMPENSATION	197,664	203,807	203,547	208,638
2.	BENEFITS	36,811	38,406	39,709	42,575
B.	SUPPORTING COSTS	4,778	5,892	2,980	3,384
1.	TRANSFER OF PERSONNEL	534	590	725	385
2.	INVESTIGATIVE SERVICES	0	1,900	200	182
3.	PERSONNEL TRAINING	4,244	3,402	2,055	2,817
II.	TRAVEL	6,691	7,336	6,239	6,489
A.	PROGRAM TRAVEL	5,078	5,883	4,911	5,108
B.	SCIENTIFIC AND TECHNICAL DEVELOPMENT TRAVEL	484	378	430	447
C.	MANAGEMENT AND OPERATIONS TRAVEL	1,129	1,075	898	934
	TOTAL, FUND REQUIREMENTS	245,944	255,441	252,475	261,086

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
	(Thousands of Dollars)			

Explanation of Fund Requirements

I. PERSONNEL AND RELATED COSTS	239,253	248,105	246,236	254,597
A. Compensation and Benefits	234,475	242,213	243,256	251,213
1. Compensation	197,664	203,807	203,547	208,638

The decrease from the 1993 Budget Estimate to the 1993 Current Estimate reflects Congressional reductions. The increase from the 1993 Current Estimate to the 1994 Estimate reflects full year funding for the 1993 pay raise, normal salary growth for promotions, within grades and merit pay, offset by the "Executive Order 12839" FTE reduction.

2. Benefits	36,811	38,406	39,709	42,575

The increase from the 1993 Budget Estimate to the 1993 Current Estimate is due to a reassessment of benefit components. Increases in FICA, retirement and TSP are partially offset by repricing the health insurance estimate. The 1994 Budget Estimate increase includes the anticipated normal growth in health benefits, the full year cost of the 1993 pay raise and increases in FERS, FICA and thrift offset by Executive Order FTE reductions.

B. Supporting Costs	4,778	5,892	2,980	3,384
1. Transfer of Personnel	534	590	725	385

The increase from the 1993 Budget Estimate to the 1993 Current Estimate reflects an increase in the number of employees who are eligible for these benefits. The decrease in the 1994 Budget Estimate is the result of

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		

fewer hires due to Executive Order FTE reductions and less use of relocation services.

2. Investigative Services	0	1,900	200	182

The 1993 Current Estimate reflects elimination of the Core conversions. The remaining dollars fund investigative services which were previously budgeted at Headquarters. The 1994 Budget Estimate reflects a decrease due to fewer new hires requiring security investigations.

3. Personnel Training	4,244	3,402	2,055	2,817

The purpose of the JSC training program is to continue to develop the skills and knowledge of civil service employees in order to more efficiently support center roles and missions. The decrease from the 1993 Budget Estimate to the 1993 Current Estimate is the result of budget constraints. The 1994 Budget Estimate increase reflects efforts to restore training deferred from 1993.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
	(Thousands of Dollars)			

Explanation of Fund Requirements

II. TRAVEL	6,691	7,336	6,239	6,489
A. Program Travel	5,078	5,883	4,911	5,108

The decrease from the 1993 Budget Estimate to the 1993 Current Estimate is a result of the re-evaluation and reallocation of available funds to meet center FTE priorities. The increase from the 1993 Current Estimate to the 1994 Budget Estimate is due to increased cooperative ventures with foreign countries and increased mission support.

B. Scientific and Technical Development Travel	484	378	430	447

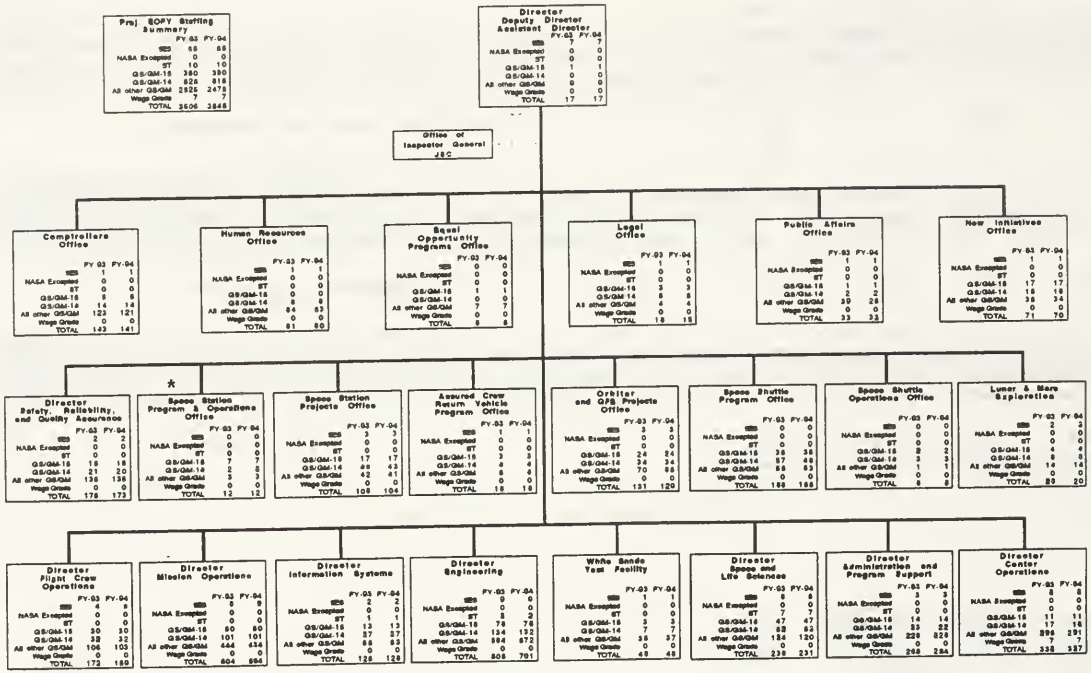
The increase from 1993 Budget Estimate to the 1993 Current Estimate and the 1994 Budget Estimate is due to increased participation in research symposia; and provides opportunities to keep the highly technical workforce abreast of "state-of-the-art" technical issues and advancements in the aerospace; scientific; and research and development communities.

C. Management and Operations Travel	1,129	1,075	898	934

The decrease from the 1993 Budget Estimate to the 1993 Current Estimate is a result of the re-evaluation and reallocation of available funds to the Scientific and Technical Development travel function and to cover FTE requirements. The increase from the 1993 Current Estimate to the 1994 Budget Estimate maintains operations in 1994 at the 1993 level.

National Aeronautics & Space Administration

Johnson Space Center



* Currently under review.

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1994 ESTIMATES

JOHN F. KENNEDY SPACE CENTER

CENTER ROLES AND MISSIONS

PRINCIPAL ROLES:

Space Shuttle Ground Operations - This includes Space Shuttle launch preparation, including Spacelab assembly and checkout and payload experiment integration; upper stages processing; orbiter, Spacelab, and Ground Support Equipment (GSE) logistics; and operation and maintenance of GSE.

Space Station - Currently under review.

Launch Vehicle Operations - This includes government oversight of all launch vehicle and payload processing and checkout activities for all NASA contracted expendable launch vehicle and upper stage launch services both at the Kennedy Space Center (KSC) and the Vandenberg Air Force Base, and for NASA launch management responsibility.

DISTRIBUTION OF FULL-TIME EQUIVALENT (FTE) WORKYEARS BY PROGRAM

KENNEDY	FY 1992 ACTUAL	FY 1993 BUDGET ESTIMATE	FY 1993 CURRENT ESTIMATE	FY 1994 BUDGET ESTIMATE
SPACE STATION AND NEW TECHNOLOGY INVESTMENTS	224	233	302	302 *
SPACE FLIGHT PROGRAMS	1,772	1,766	1,651	1,625
SPACE TRANSPORTATION CAPABILITY DEVELOPMENT	332	336	344	337
SPACE SHUTTLE PRODUCTION AND OPERATIONS	1,440	1,430	1,307	1,288
LAUNCH SERVICES	40	0	49	47
SPACE SCIENCE	97	90	94	0
PHYSICS AND ASTRONOMY	97	90	94	0
PLANETARY EXPLORATION	0	0	0	0
LIFE SCIENCES/	18	20	14	0
LIFE AND MICROGRAVITY SCIENCES	0	0	0	98
SPACE APPLICATIONS/	0	0	0	0
MISSION TO PLANET EARTH	0	0	0	0
ADVANCED CONCEPTS AND TECHNOLOGY	10	9	8	6
SPACE RESEARCH AND TECHNOLOGY	5	3	4	4
COMMERCIAL PROGRAMS	5	6	4	4
AERONAUTICAL RESEARCH AND TECHNOLOGY	0	0	0	0
TRANSATMOSPHERIC RESEARCH AND TECHNOLOGY	0	0	0	0
SPACE EXPLORATION	0	2	0	0
SAFETY RELIABILITY AND QUALITY ASSURANCE	0	0	0	0
ACADEMIC PROGRAMS	0	0	0	0
TRACKING AND DATA PROGRAMS	0	0	0	0
SUBTOTAL DIRECT	2,161	2,120	2,118	2,080
CENTER MANAGEMENT AND OPERATIONS	382	390	390	387
SUBTOTAL (FULL-TIME PERMANENT)	2,543	2,510	2,508	2,467
OTHER CONTROLLED FTE'S	13	25	13	13
TOTAL, FULL-TIME EQUIVALENTS	2,556	2,535	2,521	2,480
CORE	0	0	0	0
TOTAL, PROGRAM PLAN	2,556	2,535	2,521	2,480

*UNDER REVIEW

PROGRAM DESCRIPTION

	Permanent Civil Service Workyears
SPACE STATION AND NEW TECHNOLOGY INVESTMENTS.....	302

Currently under review.

SPACE FLIGHT PROGRAMS.....	1,625
SPACE TRANSPORTATION CAPABILITY DEVELOPMENT.....	337

KSC's role in payload operations and support is to provide facilities and support to the various customers during processing of their payloads and to coordinate with other NASA organizations in analyzing potential payload users' launch site support requirements. The Center also has responsibility for the launch site development and ground operations for the Spacelab Program. The Center advanced program planning and technology development activities include the preparation of conceptual plans for the extension or enhancement of on-going programs/projects and for new and innovative future space programs.

SPACE SHUTTLE PRODUCTION AND OPERATIONS.....	1,288

KSC is responsible for the design, modification and/or acquisition, installation, and checkout of equipment and facilities to be used in support of Space Shuttle launch requirements as well as modifications to and maintenance of existing GSE systems. KSC also provides launch construction support for Launch Complex 39 and other facilities or equipment. The operations role includes the test and checkout of each flight element as it arrives for launch; the integration of elements (orbiter, external tank, solid rocket boosters and their subsystems) into the Space Shuttle vehicle, and the integrated testing of the stacked configuration, propellant loading, and launch. KSC is also responsible for ferrying the orbiter from the landing site back to the center; orbiter refurbishment; retrieval and disassembly of the solid rocket boosters; and operation and maintenance of worldwide contingency and secondary landing sites.

	Permanent Civil Service Workyears
LAUNCH SERVICES	47

KSC is responsible for overall launch management of all NASA contracted ELV launch services at both the Eastern and Western Ranges.

LIFE SCIENCES	98

KSC will continue its support role in the integration of biomedical experiments for life sciences research on the Space Shuttle. Included is the responsibility for providing and managing a Life Sciences Principal Investigator Support Facility.

ADVANCED CONCEPTS AND TECHNOLOGY	8
SPACE RESEARCH AND TECHNOLOGY	4

Technology applications and demonstrations will continue in the areas of telerobotics, artificial intelligence, and regenerative life support.

COMMERCIAL PROGRAMS	4

This program's two primary goals are to promote and develop private sector investment in space-based technologies and to promote industrial productivity through the transfer to the nation's commercial sector of technologies that derive from NASA's Research and Development (R&D) programs and activities. To achieve its goals, Commercial Programs works to establish innovative partnerships and innovative approaches leading to new commercial enterprises, products, and services.

	Permanent Civil Service Workyears
CENTER MANAGEMENT AND OPERATIONS SUPPORT.....	387

Center Management and Operations Support provides support to all KSC organizations. The civil service personnel involved are:

Director and Staff - The Center Director, Deputy Director, and the immediate staff, e.g., Legal, Patent Counsel, Equal Opportunity, and Public Affairs.

Management Support - Personnel providing administrative and management services including resources and financial management, program control, contracting and procurement, property management, personnel management, and management systems and analysis.

Operations Support - Personnel providing for the operations and maintenance of institutional facilities, buildings, systems and equipment.

I.	PERSONNEL AND RELATED COSTS	151,872	159,687	158,915	164,130
	A. COMPENSATION AND BENEFITS	148,875	156,529	156,212	160,885
	1. COMPENSATION	124,836	131,232	130,484	133,986
	2. BENEFITS	24,039	25,297	25,728	26,899
	B. SUPPORTING COSTS	2,997	3,158	2,703	3,245
	1. TRANSFER OF PERSONNEL	647	547	524	360
	2. INVESTIGATIVE SERVICES	0	538	298	352
	3. PERSONNEL TRAINING	2,350	2,073	1,881	2,533
II.	TRAVEL	3,592	4,726	4,124	4,427
	A. PROGRAM TRAVEL	2,239	3,501	2,588	2,981
	B. SCIENTIFIC AND TECHNICAL DEVELOPMENT TRAVEL	99	114	104	106
	C. MANAGEMENT AND OPERATIONS TRAVEL	1,254	1,111	1,432	1,340
	TOTAL, FUND REQUIREMENTS	155,464	164,413	163,039	168,557

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
	(Thousands of Dollars)			

Explanation of Fund Requirements

I. PERSONNEL AND RELATED COSTS	151,872	159,687	158,915	164,130
A. Compensation and Benefits	148,875	156,529	156,212	160,885
1. Compensation	124,836	131,232	130,484	133,986

The decrease in the 1993 Current Estimate from the 1993 Budget Estimate reflects a reduction of overtime and lump sum payments associated with a lower than planned attrition rate and a reduction in FTE usage. The increase from the 1993 Current Estimate to the 1994 Budget Estimate reflects full year funding of the 1993 pay raise, normal salary growth for promotions, within grades, and merit pay, offset by the "Executive Order 12839" FTE reduction.

2. Benefits	24,039	25,297	25,728	26,899

The increase from the 1993 Budget Estimate to the 1993 Current Estimate is due to a reassessment of benefit components. Increases in FICA, medicare, retirement and TSP are partially offset by reductions in health insurance estimates. The 1994 Budget Estimate increase includes full year funding of the 1993 pay raise, health benefits increases, increases in FERS, FICA, and Thrift, offset by Executive Order reductions in FTE.

B. Supporting Costs	2,997	3,158	2,703	3,245
1. Transfer of Personnel	647	547	524	360

The decrease in the 1993 Budget Estimate to the 1993 Current Estimate and the 1994 Budget Estimate reflects a

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
	(Thousands of Dollars)			

reduction in the number and mix of planned new hires.

2. Investigative Services	0	538	298	352

The estimate for Investigative Services in the 1993 Budget reflects the transfer of budget responsibility for employee security investigations from Headquarters to the Center. The decrease in the 1993 Current Estimate from the 1993 Budget Estimate reflects a change in the definition of the ADP personnel security program and budget constraints. The 1994 increase reflects delayed renewal investigations and 1994 new hire investigations.

3. Personnel Training	2,350	2,073	1,881	2,533

The purpose of the KSC training program is to continue to develop the skills and knowledge of civil service employees in order to more efficiently support center roles and missions. The decrease from the 1993 Budget Estimate to the 1993 Current Estimate is the result of budget constraints. The 1994 Budget Estimate increase reflects the restoration of training deferred from 1993.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
	(Thousands of Dollars)			

Explanation of Fund Requirements

II. TRAVEL	3,592	4,726	4,124	4,427
A. Program Travel	2,239	3,501	2,588	2,981

The decrease in program travel from the 1993 Budget Estimate to the 1993 Current Estimate is due to budget constraints which resulted in a realignment of available funds to meet other center priorities. The increase from the 1993 Current Estimate to the 1994 Budget Estimate provides the necessary support for test, checkout and launch of space vehicles.

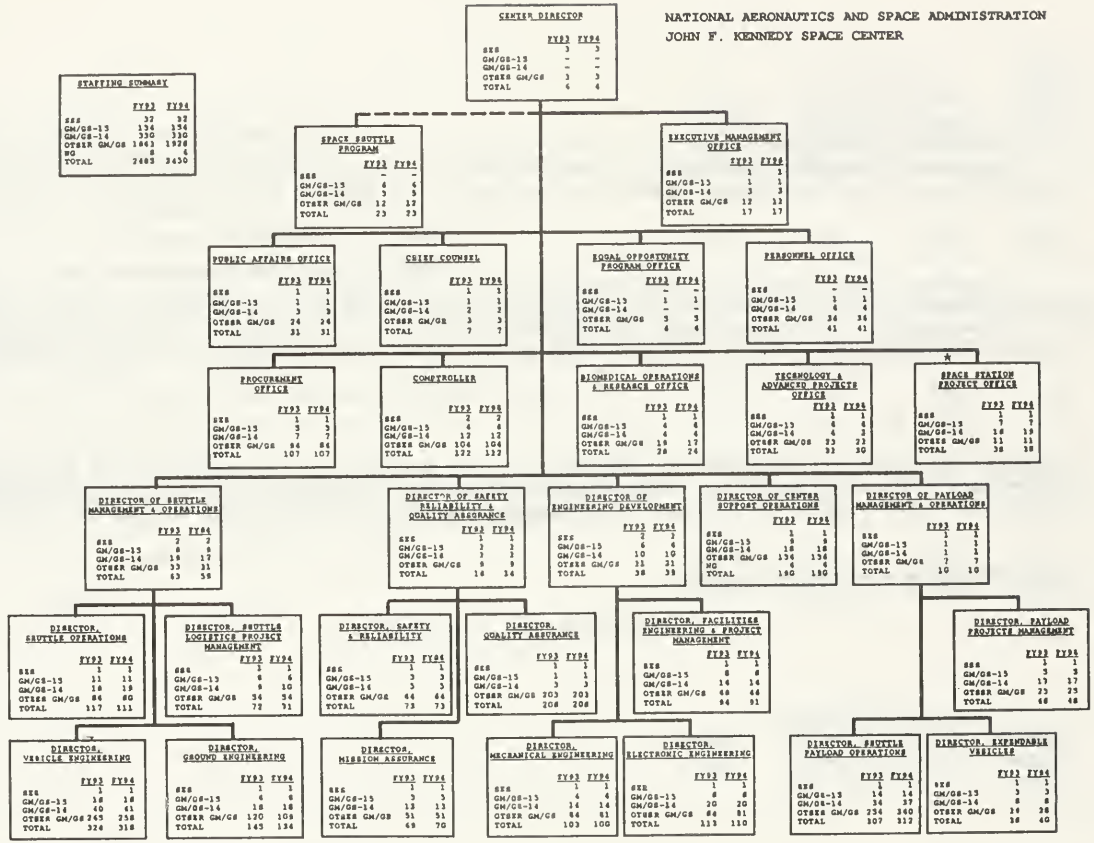
B. Scientific and Technical Development Travel	99	114	104	106

The decrease from the 1993 Budget Estimate to the 1993 Current Estimate is a result of realignment of funds to the management and operations function. The increase from the 1993 Current Estimate to the 1994 Budget Estimate is due to increased participation in research symposia; and provides opportunities to keep the highly technical workforce abreast of "state-of-the-art" technical issues and advancements in the aerospace; scientific; and research and development communities.

C. Management and Operations Travel	1,254	1,111	1,432	1,340

The increase from the 1993 Budget Estimate to the 1993 Current Estimate reflects realignment of funds from the scientific and technical development function to continue essential functional management reviews. The decrease from the 1993 Current Estimate to the 1994 Budget Estimate reflects a shifting of funds to program travel to meet program requirements.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
JOHN F. KENNEDY SPACE CENTER



* Currently under review.

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1994 ESTIMATES

GEORGE C. MARSHALL SPACE FLIGHT CENTER

CENTER ROLES AND MISSIONS

PRINCIPAL ROLES:

Propulsion Systems - Design, development, and procurement of propulsion elements of the Space Transportation System including the Advanced Solid Rocket Motor (ASRM). Advanced program and new technology development efforts are focused on analysis and definition of propulsion/transportation systems to meet national needs for the next 30 to 40 years.

Launch Vehicles - Design, development, integration, and testing of launch vehicles and space transportation systems and system definition for future manned and unmanned launch systems.

Upper Stages - Design, development, procurement, and integration of upper stages such as the Inertial Upper Stage.

Spacelab Payload Mission Management - Program management, systems engineering, development of payload carriers, procurement, flight and ground operations support engineering for the program; integration of microgravity flight experiments and science and applications flight experiments for Spacelab; operation of the integrated payload carrier systems, and mission science operation training of mission and payload specialists.

Space Station Freedom - Currently under review.

Advanced X-Ray Astrophysics Facility - Design, development, testing and manufacture of two observatories that will provide detailed, long-term study of x-ray emissions from the universe and the phenomena that produce them.

SUPPORTING ROLES:

Research and Technology - Conduct of research and technology in the propulsion and power systems, structural systems, materials and manufacturing processes, microgravity science systems, software engineering, environmental control/life support systems, earth and astronomical science systems, and guidance and control systems.

Advanced Development and Studies - Development of selected technologies into specific flight subsystems or systems application, and definition of space systems to meet future Planetary Exploration needs.

Science - Conduct ground-based research and flight experiments in selected science areas with major emphasis in solar physics, astrophysics, and atmospheric, Earth, and microgravity science.

DISTRIBUTION OF FULL-TIME EQUIVALENT (FTE) WORKYEARS BY PROGRAM

MARSHALL	FY 1992 ACTUAL	FY 1993 BUDGET ESTIMATE	FY 1993 CURRENT ESTIMATE	FY 1994 BUDGET ESTIMATE
SPACE STATION AND NEW TECHNOLOGY INVESTMENTS	557	579	706	706 *
SPACE FLIGHT PROGRAMS	1,613	1,447	1,275	1,132
SPACE TRANSPORTATION CAPABILITY DEVELOPMENT	705	570	443	370
SPACE SHUTTLE PRODUCTION AND OPERATIONS	908	877	832	762
LAUNCH SERVICES	77	0	57	10
SPACE SCIENCE	561	629	871	529
PHYSICS AND ASTRONOMY	559	623	671	529
PLANETARY EXPLORATION	2	6	0	0
LIFE SCIENCES/	0	0	0	0
LIFE AND MICROGRAVITY SCIENCES	0	0	0	405
SPACE APPLICATIONS/	228	241	272	0
MISSION TO PLANET EARTH	0	0	0	117
ADVANCED CONCEPTS AND TECHNOLOGY	169	256	149	159
SPACE RESEARCH AND TECHNOLOGY	149	234	130	138
COMMERCIAL PROGRAMS	20	22	19	21
AERONAUTICAL RESEARCH AND TECHNOLOGY	0	0	0	0
TRANSATMOSPHERIC RESEARCH AND TECHNOLOGY	2	0	0	0
SPACE EXPLORATION	10	0	28	0
SAFETY RELIABILITY AND QUALITY ASSURANCE	0	0	0	0
ACADEMIC PROGRAMS	0	0	0	0
TRACKING AND DATA PROGRAMS	16	17	17	17
SUBTOTAL DIRECT	3,233	3,169	3,175	3,075
CENTER MANAGEMENT AND OPERATIONS	502	481	485	485
SUBTOTAL (FULL-TIME PERMANENT)	3,735	3,650	3,660	3,560
OTHER CONTROLLED FTE'S	11	11	11	11
TOTAL, FULL-TIME EQUIVALENTS	3,746	3,661	3,671	3,571
CORE	0	0	0	0
TOTAL, PROGRAM PLAN	3,746	3,661	3,671	3,571

*UNDER REVIEW

PROGRAM DESCRIPTION

	Permanent Civil Service Workyears
SPACE STATION AND NEW TECHNOLOGY INVESTMENTS.....	706

Currently under review.

SPACE FLIGHT PROGRAMS.....	1,132
SPACE TRANSPORTATION CAPABILITY DEVELOPMENT.....	370

Spacelab program management and system engineering; integration of European Space Agency (ESA) and NASA-provided hardware and software; mission integration and preparation for Spacelab and other missions involving Spacelab hardware. Management of the Solid Propulsion Integrity Program (SPIP) to improve the engineering technology base for Solid Rocket Motor (SRM). Definition and implementation of in-house and contracted advanced system studies, advanced development tasks, and flight demonstrations to establish fundamental planning and decision making data. Definition of launch vehicles and engine requirements to support current and future national needs.

	Permanent Civil Service Workyears
SPACE SHUTTLE PRODUCTION AND OPERATIONS.....	762

Analysis of the flight hardware including the Solid Rocket Booster (SRB), Solid Rocket Motor (SRM), Space Shuttle Main Engine (SSME), and External Tank (ET). This effort also provides main engines for the Space Shuttle orbiter fleet and continues a logistics support, and standard operational services for the Space Shuttle. Other activities include the production, overhaul, and acquisition of hardware for Shuttle flights including the procurement of external tanks, solid rocket motors and propellants, and booster hardware.

LAUNCH SERVICES.....	10

Support of the Inertial Upper Stage (IUS) missions with readiness reviews, joint integrated flight simulations, launch and flight operations support, and post flight evaluation of the upper stage performance. Management of the development, production and launch support of the Small Expendable Deployer System (SEDS).

SPACE SCIENCE	529
PHYSICS AND ASTRONOMY.....	529

Marshall Space Flight Center (MSFC) continues as the lead Center for the development and operations for the AXAF mission. These missions use a shuttle launched observatory x-ray telescope for studies of the universe in the spectral region between that observed by the Hubble Space Telescope in the optical region and the Compton Observatory in the gamma ray region. MSFC will continue its responsibilities for managing and planning Shuttle/Spacelab activities of the Atmospheric Laboratory for Applications and Science (ATLAS), International Microgravity Laboratory (IML), United States Microgravity Laboratory (USML), and other dedicated payload missions.

Permanent Civil
Service Workyears

LIFE AND MICROGRAVITY SCIENCES..... 405

The Materials Processing program provides the fundamental science and technology for processing materials under conditions that allow detailed examination of the constraints imposed by gravitational forces. Research continues in the areas of crystal growth, fluid physics, biophysics, solidification mechanics, chemistry and polymetric materials.

MSFC will also design, develop, and test payload carriers; develop payload definitions; integrate microgravity flight experiments and science and applications flight experiments for Spacelab; operate integrated payload systems; and train mission and payload specialists in the science aspects of their missions.

MISSION TO PLANET EARTH..... 117

Theoretical, field, and laboratory experimental research will be conducted in the global weather, severe storms, and local weather areas. Efforts will be concentrated on improving understanding of severe storms, local and global scale weather systems, and in establishing criteria for Shuttle missions to gather data required to understand and predict severe storms and atmospheric conditions.

ADVANCED CONCEPTS AND TECHNOLOGY..... 159

SPACE RESEARCH AND TECHNOLOGY..... 138

The space research and technology activities are in earth-to-orbit propulsion, cryogenic engines, in-space technology experiments, automation and robotics, and science and data analysis for the Long Duration Exposure facility.

	Permanent Civil Service Workyears
COMMERCIAL PROGRAMS.....	21

This program's two primary goals are to promote and develop private sector investment in space-based technologies and to promote industrial productivity through the transfer to the nation's commercial sector of technologies that derive from NASA's Research and Development (R&D) programs and activities. To achieve its goals, Commercial Programs works to establish innovative partnerships and innovative approaches leading to new commercial enterprises, products, and services.

TRACKING AND DATA PROGRAMS.....	17

Management and maintenance of the Program Support Communications Network which provides communications hardware, software, and transmission medium that inter-connects NASA Headquarters, Field Installations, and major contractor locations for the transfer of data, voice, and video.

CENTER MANAGEMENT AND OPERATIONS SUPPORT.....	485

Center Management and Operations Support is provided to all MSFC organizations and includes the following:

Director and Staff - The Center Director, Deputy Director, and immediate staff, e.g., Comptroller, Human Resources and Administrative Support, Legal, Patent Counsel, Equal Opportunity, Public Affairs.

Management Support - Management and support services to all levels of Center management, both program and functional.

Operations Support - Operation and maintenance of institutional facilities, buildings, systems, and equipment.

68-668 O—93——25

		1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)			
I.	PERSONNEL AND RELATED COSTS	225,463	230,002	228,622	236,496
A.	COMPENSATION AND BENEFITS	221,554	226,472	226,372	233,196
1.	COMPENSATION	185,295	187,434	188,747	193,686
2.	BENEFITS	36,259	39,038	37,625	39,510
B.	SUPPORTING COSTS	3,909	3,530	2,250	3,300
1.	TRANSFER OF PERSONNEL	652	738	650	800
2.	INVESTIGATIVE SERVICES	0	400	200	200
3.	PERSONNEL TRAINING	3,257	2,392	1,400	2,300
II.	TRAVEL	6,194	7,135	6,108	6,351
A.	PROGRAM TRAVEL	4,959	6,195	5,165	5,296
B.	SCIENTIFIC AND TECHNICAL DEVELOPMENT TRAVEL	219	200	200	275
C.	MANAGEMENT AND OPERATIONS TRAVEL	1,016	740	743	780
	TOTAL, FUND REQUIREMENTS	231,657	237,137	234,730	242,847

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
	(Thousands of Dollars)			
Explanation of Fund Requirements				
I. PERSONNEL AND RELATED COSTS	225,463	230,002	228,622	236,496
A. Compensation and Benefits	221,554	226,472	226,372	233,196
1. Compensation	185,295	187,434	188,747	193,686

The increase in the 1993 Current Estimate from the 1993 Budget Estimate reflects a re-estimate of costs due to lower attrition in 1992 and higher salaried new hires than previously planned. This contributes to a higher base salary at the beginning of 1993. The increase in the 1994 Budget Estimate reflects full year funding of the 1993 pay raise, normal salary growth due to promotions, within grades, and merit pay, offset by the "Executive Order 12839" FTE reduction.

2. Benefits	36,259	39,038	37,625	39,510

The decrease from the 1993 Budget Estimate to the 1993 Current Estimate is the result of repricing due to lower than anticipated benefits. The 1994 Budget Estimate increase results from full year funding of the 1993 pay raise, increases in retirement benefits, offset by Executive Order reductions in FTE.

B. Supporting Costs	3,909	3,530	2,250	3,300
1. Transfer of Personnel	652	738	650	800

The decrease in the 1993 Current Estimate from the 1993 Budget Estimate reflects a reduction in the number of planned new hires. The increase in the 1994 Budget Estimate allows for additional hires requiring the use of

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
	(Thousands of Dollars)			

relocation benefits.

2. Investigative Services	0	400	200	200

The decrease from the 1993 Budget Estimate to the 1993 Current Estimate reflects the elimination of Support Service Contractor Investigations.

3. Personnel Training	3,257	2,392	1,400	2,300

The purpose of the MSFC training program is to continue to develop the skills and knowledge of civil service employees in order to more efficiently support center roles and missions. The decrease from the 1993 Budget Estimate to the 1993 Current Estimate results from budget constraints. The increase from the 1993 Current Estimate to the 1994 Budget Estimate reflects the restoration of deferred 1993 training.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
	(Thousands of Dollars)			

Explanation of Fund Requirements

II. TRAVEL	6,194	7,135	6,108	6,351
A. Program Travel	4,959	6,195	5,165	5,296

The decrease from the 1993 Budget Estimate to the 1993 Current Estimate is due to a constrained budget. The 1994 Budget Estimate reflects the continued level of effort as experienced in 1993.

B. Scientific and Technical Development Travel	219	200	200	275

The increase from the 1993 Budget Estimate to the 1994 Current Estimate is due to increased participation in research symposia; and provides opportunities to keep the highly technical workforce abreast of "state-of-the-art" technical issues and advancements in the aerospace; scientific; and research and development communities.

C. Management and Operations Travel	1,016	740	743	780

The decrease from the 1993 Budget Estimate to the 1993 Current Estimate is due to a constrained budget. The increase in the 1994 Budget Estimate is due primarily to inflation and continuous efforts to provide functional management oversight and review.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
GEORGE C. MARSHALL SPACE FLIGHT CENTER

OFFICE OF DIRECTOR

	FY93	FY94
SES	4	4
GS-16		
GS-15	1	1
GS-14		
ALL OTHER GS	5	5
AD POS		
TOTAL PERM	10	10

MSFC SUMMARY

	FY93	FY94
SES	61	61
GS-16		
GS-15	237	230
GS-14	636	629
ALL OTHER GS	2679	2583
AD POS	4	7
TOTAL PERM	3617	3507

ASSOCIATE DIRECTOR FOR SCIENCE

	FY93	FY94
SES	1	1
GS-16		
GS-15	1	1
GS-14		
ALL OTHER GS	1	1
AD POS.		
TOTAL PERM	3	3

EXECUTIVE STAFF

	FY93	FY94
SES		
GS-16		
GS-15	1	1
GS-14	2	2
ALL OTHER GS	12	12
AD POS		
TOTAL PERM	15	15

SAFETY & MISSION ASSURANCE OFFICE

	FY93	FY94
SES	2	2
GS-16		
GS-15	9	9
GS-14	33	33
ALL OTHER GS	140	131
AD POS		
TOTAL PERM	184	175

PUBLIC AFFAIRS OFFICE

	FY93	FY94
SES		
GS-16		
GS-15	1	1
GS-14	3	3
ALL OTHER GS	19	16
AD POS		
TOTAL PERM	23	20

CHIEF COUNSEL

	FY93	FY94
SES	1	1
GS-16		
GS-15	2	2
GS-14	5	5
ALL OTHER GS	9	9
AD POS		
TOTAL PERM	17	17

CENTER COMPTROLLER

	FY93	FY94
SES	1	1
GS-16		
GS-15	6	6
GS-14	18	18
ALL OTHER GS	107	105
AD POS		
TOTAL PERM	132	130

HUMAN RESOURCES AND ADMIN. SUPPORT OFFICE

	FY93	FY94
SES	1	1
GS-16		
GS-15	2	2
GS-14	13	13
ALL OTHER GS	167	164
AD POS.		
TOTAL PERM	183	180

EQUAL OPPORTUNITY OFFICE

	FY93	FY94
SES		
GS-16		
GS-15	1	1
GS-14		
ALL OTHER GS	6	6
AD POS		
TOTAL PERM	7	7

SPACE SHUTTLE PROJECTS OFFICE

	FY93	FY94
SES	5	5
GS-16		
GS-15	18	18
GS-14	21	21
ALL OTHER GS	84	76
AD POS		
TOTAL PERM	128	120

SPACE SYSTEMS PROJECT OFFICE

	FY93	FY94
SES	1	1
GS-16		
GS-15	4	4
GS-14	6	6
ALL OTHER GS	11	11
AD POS		
TOTAL PERM	22	22

OBSERVATORY PROJECTS OFFICE

	FY93	FY94
SES	3	3
GS-16		
GS-15	6	6
GS-14	13	13
ALL OTHER GS	20	20
AD POS		
TOTAL PERM	42	42

PAYLOAD PROJECTS OFFICE

	FY93	FY94
SES	3	3
GS-16		
GS-15	15	15
GS-14	35	35
ALL OTHER GS	51	47
AD POS		
TOTAL PERM	104	100

* SPACE STATION PROJECTS OFFICE

	FY93	FY94
SES	2	2
GS-16		
GS-15	4	4
GS-14	18	18
ALL OTHER GS	32	32
AD POS		
TOTAL PERM	56	56

HEAVY LIFT LAUNCH VEHICLE DEFINITION OFC

	FY93	FY94
SES	1	1
GS-16		
GS-15		
GS-14	9	9
ALL OTHER GS	10	7
AD POS	3	3
TOTAL PERM	23	20

* SPC STATION FREEDOM PROG ELEM INTEG OFC

	FY93	FY94
SES		
GS-16		
GS-15	2	2
GS-14	4	4
ALL OTHER GS	2	2
AD POS		
TOTAL PERM	8	8

PROGRAM DEVELOPMENT

	FY93	FY94
SES	4	4
GS-16		
GS-15	19	19
GS-14	32	32
ALL OTHER GS	85	80
AD POS		
TOTAL PERM	140	135

SCIENCE AND ENGINEERING

	FY93	FY94
SES	26	26
GS-16		
GS-15	127	120
GS-14	378	371
ALL OTHER GS	1580	1526
AD POS	1	4
TOTAL PERM	2112	2047

INSTITUTIONAL AND PROGRAM SUPPORT

	FY93	FY94
SES	6	6
GS-16		
GS-15	18	18
GS-14	46	46
ALL OTHER GS	338	330
AD POS		
TOTAL PERM	408	400

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NOTE ALL MANPOWER SHOWN IN EOY
02-24-93

RPM 3-12

* Currently under review.

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1994 ESTIMATES

JOHN C. STENNIS SPACE CENTER

CENTER ROLES AND MISSIONS

PRINCIPAL ROLES:

Space Shuttle - Provides, maintains, and manages the facilities and the related capabilities required for the continued development and acceptance testing of the Space Shuttle Main Engines.

Advanced Solid Rocket Motor - Provides project management for all Advanced Solid Rocket Motor (ASRM) activities at Stennis Space Center (SSC) including contractor management, facility design and construction, and ASRM test support functions.

National Aerospace Plane - Provides management oversight of National Aerospace Plane (NASP) Propulsion Test Facility design modifications and construction. Design, construction, and activation of the High Heat Flux Facility (HHFF) for high temperature material testing is underway. This Center also has project responsibility for implementing the test activities of the NASP propulsion project requirements.

Global Change Research - Conducts fundamental and applied research, develops advanced airborne sensors and data/information systems, and conducts test and evaluation activities of remote sensing technology.

Support to Tenant Agencies - Provides technical and institutional support to resident agencies.

DISTRIBUTION OF FULL-TIME EQUIVALENT (FTE) WORKYEARS BY PROGRAM

STENNIS	FY 1992 ACTUAL	FY 1993 BUDGET ESTIMATE	FY 1993 CURRENT ESTIMATE	FY 1994 BUDGET ESTIMATE
SPACE STATION AND NEW TECHNOLOGY INVESTMENTS	0	0	0	0 *
SPACE FLIGHT PROGRAMS	117	116	96	94
SPACE TRANSPORTATION CAPABILITY DEVELOPMENT	59	60	46	44
SPACE SHUTTLE PRODUCTION AND OPERATIONS	58	56	50	50
LAUNCH SERVICES	0	0	0	0
SPACE SCIENCE	0	0	0	0
PHYSICS AND ASTRONOMY	0	0	0	0
PLANETARY EXPLORATION	0	0	0	0
LIFE SCIENCES/	0	1	0	0
LIFE AND MICROGRAVITY SCIENCES	0	0	0	0
SPACE APPLICATIONS/	9	9	5	0
MISSION TO PLANET EARTH	0	0	0	5
ADVANCED CONCEPTS AND TECHNOLOGY	13	15	16	16
SPACE RESEARCH AND TECHNOLOGY	2	0	4	4
COMMERCIAL PROGRAMS	11	15	12	12
AERONAUTICAL RESEARCH AND TECHNOLOGY	0	0	0	0
TRANSATMOSPHERIC RESEARCH AND TECHNOLOGY	6	0	18	18
SPACE EXPLORATION	0	0	0	0
SAFETY RELIABILITY AND QUALITY ASSURANCE	2	0	1	1
ACADEMIC PROGRAMS	1	0	2	2
TRACKING AND DATA PROGRAMS	0	0	0	0
SUBTOTAL DIRECT	148	141	138	136
CENTER MANAGEMENT AND OPERATIONS	73	75	75	75
SUBTOTAL (FULL-TIME PERMANENT)	221	216	213	211
OTHER CONTROLLED FTE'S	5	6	5	5
TOTAL, FULL-TIME EQUIVALENTS	226	222	218	216
CORE	0	28	0	0
TOTAL, PROGRAM PLAN	226	250	218	216

*UNDER REVIEW

PROGRAM DESCRIPTION

	Permanent Civil Service Workyears
SPACE FLIGHT PROGRAMS	94
SPACE TRANSPORTATION CAPABILITY DEVELOPMENT	44

SSC provides maintenance and management of the facilities needed to test propulsion concepts and technologies.

SPACE SHUTTLE PRODUCTION AND OPERATIONS	50

Provides maintenance and management of the facilities and the related capabilities required for the development and acceptance testing of the Space Shuttle Main Engines.

MISSION TO PLANET EARTH	5

Science and technology laboratories conduct research investigations in the application of remotely-sensed data. This includes conducting applied research investigations for the application of new sensor data to prioritize information requirements of national concern in the areas of agricultural productivity, geological explorations, and land resources management. SSC also conducts research and development into applications for non-remote sensing, primarily in such areas as environmental system development and closed ecosystems development.

ADVANCED CONCEPTS AND TECHNOLOGY	16
SPACE RESEARCH AND TECHNOLOGY	4

Stennis Space Center conducts technology development projects, including, Robust Pump, Hydrogen Leak Detection and Plume Diagnostics. SSC also supports strategic planning and representation on discipline area and Space Systems working groups.

	Permanent Civil Service Workyears
COMMERCIAL PROGRAMS.....	12

This program's two primary goals are to promote and develop private sector investment in space-based technologies and to promote industrial productivity through the transfer to the nation's commercial sector of technologies that derive from NASA's Research and Development (R&D) programs and activities. To achieve its goals, Commercial Programs works to establish innovative partnerships and innovative approaches leading to new commercial enterprises, products, and services.

TRANSATMOSPHERIC RESEARCH AND TECHNOLOGY.....	18

The SSC provides management oversight to the NASP Propulsion Test Facility design, construction, planning and eventual conduct of the NASP propulsion systems tests.

With the expected completion of the High Heat Flux Facility (HHFF), testing will begin on 20 X 20 NASP sample panels. The HHFF gas generator will test panels at temperatures between 4,000 and 6,000 degrees F. Data received will enable NASP engineers to determine the extent of damage to the materials as well as the distribution of heat throughout the panels.

SAFETY, RELIABILITY, & QUALITY ASSURANCE.....	1

SSC provides technical support in monitoring various SR&QA tasks.

ACADEMIC PROGRAMS.....	2

SSC provides support to the Tri-State Education Initiative which foster involvement and interaction within the Tennessee, Alabama and Mississippi school systems of the Consortium. It serves students, parents, higher learning institutions, and involved industry.

	Permanent Civil Service Workyears
CENTER MANAGEMENT AND OPERATIONS.....	75

Center Management and Operations Support is defined as that support provided to all SSC organizations which cannot be identified exclusively to a single program or project. The civil service personnel involved are:

Director and Staff - The Installation Director, Deputy Director, and immediate staff, e.g., Legal, Equal Opportunity, and Public Affairs.

Management Support - Those who provide information and management services supporting all levels of Center management, both program and functional.

Operations Support - Those who manage or provide for the operation and maintenance of institutional facilities, buildings, systems and equipment.

		1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)			
I.	PERSONNEL AND RELATED COSTS	13,688	15,641	14,096	14,710
	A. COMPENSATION AND BENEFITS	13,349	13,909	13,819	14,380
	1. COMPENSATION	10,948	11,359	11,233	11,645
	2. BENEFITS	2,401	2,550	2,586	2,735
	B. SUPPORTING COSTS	339	1,732	277	330
	1. TRANSFER OF PERSONNEL	4	180	125	145
	2. INVESTIGATIVE SERVICES	52	1,376	12	23
	3. PERSONNEL TRAINING	283	176	140	162
II.	TRAVEL	576	681	547	569
	A. PROGRAM TRAVEL	305	284	290	302
	B. SCIENTIFIC AND TECHNICAL DEVELOPMENT TRAVEL	103	185	98	102
	C. MANAGEMENT AND OPERATIONS TRAVEL	168	212	159	165
	TOTAL, FUND REQUIREMENTS	14,264	16,322	14,643	15,279

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
	(Thousands of Dollars)			
Explanation of Fund Requirements				
I. PERSONNEL AND RELATED COSTS	13,688	15,641	14,096	14,710
A. Compensation and Benefits	13,349	13,909	13,819	14,380
1. Compensation	10,948	11,359	11,233	11,645

The decrease in the 1993 Current Estimate from the 1993 Budget Estimate is due to the Congressional Budget reductions. The 1994 Budget Estimate increase is due to full year funding of the 1993 pay raise, normal salary growth for promotions, within grades, and merit pay, offset by the "Executive Order 12839" FTE reduction.

2. Benefits	2,401	2,550	2,586	2,735

The increase between the 1993 Current Estimate and the 1993 Budget Estimate reflects changes in FERS, TSP and FICA costs. The 1994 Budget Estimate increase reflects full year funding of the 1993 pay raise, increases in retirement and health benefits, offset by Executive Order reductions in FTE.

B. Supporting Costs	339	1,732	277	330
1. Transfer of Personnel	4	180	125	145

This supporting costs category includes movement of household goods, subsistence and temporary expenses, real estate costs and miscellaneous moving expenses related to change of duty station. The decrease in the 1993 Current Estimate from the 1993 Budget Estimate reflects a reduction in the number of hires. The 1994 Estimate reflects an increase due to inflation and a new hire using these relocation benefits.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
	(Thousands of Dollars)			
2. Investigative Services	52	1,376	12	23

The FY 1993 Budget Estimate reflects the cancellation of the Project Core conversion program and the transfer of security investigations from Headquarters to the centers. The 1994 Estimate reflects new hires requiring these investigations.

3. Personnel Training	283	176	140	162

The purpose of the SSC training program is to continue to develop the skills and knowledge of civil service employees in order to more efficiently support center roles and missions. In 1992 a "Learning Center" was developed at Stennis Space Center. Courses purchased for the "Learning Center" will be used in 1993 and subsequent years. The decrease from the 1993 Budget Estimate to the 1993 Current Estimate is due to funding constraints. The 1994 Budget Estimate restores deferred 1993 training.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
	(Thousands of Dollars)			

Explanation of Fund Requirements

II. TRAVEL	576	681	547	569
A. Program Travel	305	284	290	302

The 1994 Budget Estimate maintains 1993 levels of operation.

B. Scientific and Technical Development Travel	103	185	98	102

The decrease from the 1993 Budget Estimate to the 1993 Current Estimate is due to required budget reductions. The increase from the 1993 Current Estimate to the 1994 Budget Estimate is due to inflation.

C. Management and Operations Travel	168	212	159	165

The decrease from the 1993 Budget Estimate to the 1993 Current Estimate is due to required budget reductions. The increase from the 1993 Current Estimate to the 1994 Budget Estimate is due to inflation.

ORGANIZATION CHART

FY 1994 CONGRESSIONAL BUDGET
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
JOHN C. STENNIS SPACE CENTER

SSC SUMMARY STAFFING

	FY93	FY94
SES	6	6
AD	1	1
GS/GM 15	12	12
GS/GM 14	27	27
All Other GS/GM	168	168
TOTAL PERMANENT	214	214

OFFICE OF THE DIRECTOR

	FY93	FY94
SES	3	3
GS/GM 15	0	0
GS/GM 14	1	1
All Other GS/GM	4	4
TOTAL PERMANENT	8	8

ASRM PROJECT OFFICE

	FY93	FY94
GS/GM 15	1	1
GS/GM 14	1	1
All Other GS/GM	2	2
TOTAL PERMANENT	4	4

MLS PROJECT OFFICE

	FY93	FY94
GS/GM 15	1	1
GS/GM 14	1	1
All Other GS/GM	3	3
TOTAL PERMANENT	5	5

CHIEF COUNSEL

	FY93	FY94
GS/GM 15	1	1
GS/GM 14	0	0
All Other GS/GM	3	3
TOTAL PERMANENT	4	4

PUBLIC AFFAIRS OFFICE

	FY93	FY94
GS/GM 14	1	1
All Other GS/GM	2	2
TOTAL PERMANENT	3	3

HUMAN RESOURCES OFFICE

	FY93	FY94
GS/GM 14	1	1
All Other GS/GM	5	4
TOTAL PERMANENT	6	5

SR AND QA OFFICE

	FY93	FY94
GS/GM 14	1	1
All Other GS/GM	9	9
TOTAL PERMANENT	10	10

COMPTROLLER

	FY93	FY94
GS/GM 15	1	1
GS/GM 14	2	2
All Other GS/GM	24	24
TOTAL PERMANENT	27	27

PROCUREMENT OFFICE

	FY93	FY94
GS/GM 15	1	1
GS/GM 14	3	3
All Other GS/GM	14	15
TOTAL PERMANENT	18	19

PROPULSION TEST OPERATIONS

	FY93	FY94
SES	1	1
GS/GM 15	3	3
GS/GM 14	3	3
All Other GS/GM	40	40
TOTAL PERMANENT	47	47

SCIENCE & TECHNOLOGY LABORATORY

	FY93	FY94
SES	1	1
AD	1	1
GS/GM 15	3	3
GS/GM 14	6	6
All Other GS/GM	26	26
TOTAL PERMANENT	37	37

CENTER OPERATIONS OFFICE

	FY93	FY94
SES	1	1
GS/GM 15	1	1
GS/GM 14	7	7
All Other GS/GM	36	36
TOTAL PERMANENT	45	45

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1994 ESTIMATES

GODDARD SPACE FLIGHT CENTER

CENTER ROLES AND MISSIONS

PRINCIPAL ROLES:

Earth Orbiting Spacecraft Development, On-Orbit Servicing And Flight Operations - Develops spacecraft propulsion and supporting technology.

Space And Earth Sciences - Implements science experiments in astronomy, solar physics, high energy astrophysics, solar terrestrial studies, and atmospheric, oceanic, and land processes.

Tracking And Data Acquisition Systems And Support Operations - Plans, develops, and operates tracking facilities and provides data processing, communications, and mission control; supports earth orbital spacecraft, aeronautical, balloon and sounding rocket research; and implements Shuttle networks. Operates the Tracking and Data Relay Satellite System (TDRSS).

Launch Range And Research Airport Management And Operations - Plans and operates the Wallops launch range, and the associated aircraft and research airport.

Launch Services - Procures and manages the medium and small class expendable launch vehicle services.

Sounding Rocket Development, Procurement, And Operations - Manages and supports the NASA sounding rocket program.

Balloon Program - Manages the NASA balloon program providing technical oversight and direction to the balloon activities conducted for universities and other scientific groups and directs the research and development effort for balloon related technologies.

Spacelab Payload Development - Develops, integrates, and processes data for Spacelab payloads in astrophysics, solar terrestrial physics, and astronomy.

Attached Payloads - Manages and develops low-cost reusable carrier systems which accommodate a variety of payloads to be flown on Shuttle missions.

Information Systems - Applies advanced computer and information systems technology in support of science programs, including data management, scientific computing, networking, archiving, and distribution.

SUPPORTING ROLES:

Planetary Science - Develops and applies techniques for the investigation and analysis of planetary atmospheres.

Aerospace Flight Test Support - Plans and conducts launches of scientific payloads, aeronautical tests and other research, development and related activities as requested by elements of NASA, the Department of Defense, other Government agencies, and the worldwide scientific community.

DISTRIBUTION OF FULL-TIME EQUIVALENT (FTE) WORKYEARS BY PROGRAM

GODDARD	FY 1992 ACTUAL	FY 1993 BUDGET ESTIMATE	FY 1993 CURRENT ESTIMATE	FY 1994 BUDGET ESTIMATE
SPACE STATION AND NEW TECHNOLOGY INVESTMENTS	9	0	0	0 *
SPACE FLIGHT PROGRAMS	75	136	71	57
SPACE TRANSPORTATION CAPABILITY DEVELOPMENT	66	62	61	48
SPACE SHUTTLE PRODUCTION AND OPERATIONS	9	74	10	9
LAUNCH SERVICES	51	0	53	52
SPACE SCIENCE	1,462	1,420	1,436	1,414
PHYSICS AND ASTRONOMY	1,347	1,304	1,315	1,287
PLANETARY EXPLORATION	115	116	121	127
LIFE SCIENCES/	1	1	1	0
LIFE AND MICROGRAVITY SCIENCES	0	0	0	1
SPACE APPLICATIONS/	915	990	991	0
MISSION TO PLANET EARTH	0	0	0	1,003
ADVANCED CONCEPTS AND TECHNOLOGY	83	96	49	48
SPACE RESEARCH AND TECHNOLOGY	69	83	41	41
COMMERCIAL PROGRAMS	14	13	8	7
AERONAUTICAL RESEARCH AND TECHNOLOGY	13	16	16	19
TRANSATMOSPHERIC RESEARCH AND TECHNOLOGY	0	0	0	0
SPACE EXPLORATION	8	0	3	0
SAFETY RELIABILITY AND QUALITY ASSURANCE	15	10	14	15
ACADEMIC PROGRAMS	0	0	0	0
TRACKING AND DATA PROGRAMS	607	592	594	574
SUBTOTAL DIRECT	3,239	3,261	3,230	3,183
CENTER MANAGEMENT AND OPERATIONS	749	724	724	711
SUBTOTAL (FULL-TIME PERMANENT)	3,988	3,985	3,954	3,694
OTHER CONTROLLED FTE'S	26	32	24	24
TOTAL, FULL-TIME EQUIVALENTS	4,014	4,017	3,978	3,918
CORE	0	87	0	0
TOTAL, PROGRAM PLAN	4,014	4,104	3,978	3,918

*UNDER REVIEW

PROGRAM DESCRIPTION

	Permanent Civil Service Workyears
SPACE FLIGHT PROGRAMS.....	57
SPACE TRANSPORTATION CAPABILITY DEVELOPMENT.....	48

Goddard Space Flight (GSFC) Center manages development of the Hitchhiker, a reusable carrier system which provides increased flight opportunities with reduced leadtime while maximizing Shuttle load factors and minimizing spaceflight costs.

SPACE SHUTTLE PRODUCTION AND OPERATIONS.....	9

GSFC manages and coordinates the Agency's Get Away Special (GAS) program. Center personnel coordinate with international experimenters (including private citizens, high schools, universities, and industry) who have procured payload space on the Shuttle.

LAUNCH SERVICES.....	52

GSFC has management responsibility for the small and medium class expendable launch vehicle services used to put a wide variety of spacecraft into a broad spectrum of orbits. The Delta launch vehicle will be used to launch the Global Geospace Science (GGS) Wind and Polar missions and the cooperative Radarsat mission. The Pegasus vehicle will launch the Total Ozone Mapping Mission (TOMS) and Fast Auroral Snapshot Explorer (FAST).

	Permanent Civil Service Workyears
SPACE SCIENCE	1,414
PHYSICS AND ASTRONOMY	1,287

GSFC manages activities in the following discipline areas: gamma ray astronomy, X-ray astronomy, ultraviolet and optical astronomy, infrared and radio astronomy, particle astrophysics, solar physics, interplanetary physics, planetary magnetospheres, and astrochemistry. This includes development of major spacecraft missions, such as the GGS Wind and Polar spacecraft, the X-ray Timing Explorer, the Advanced Composition Explorer, and the Fast Auroral Snapshot (FAST) and Submillimeter Wave Astronomy Satellite (SWAS) small explorers. GSFC is also responsible for conducting the mission operations for a variety of operating spacecraft (e.g., Compton Gamma Ray Observatory, Cosmic Background Explorer, etc.), including the operations, maintenance and servicing of the Hubble Space Telescope, including the first servicing mission planned for early FY 1994. Other activities include managing NASA's sounding rocket and scientific balloon program, as well as, the National Space Science Data Center.

PLANETARY EXPLORATION	127

The science activity studies the physics of interplanetary and planetary space environments. The GSFC research group participates in Galileo, Mars Observer, and CASSINI instrument development, mission operations, and data analysis activity.

LIFE AND MICROGRAVITY SCIENCES	1

GSFC provides support for the mission management for the Diffuse X-Ray Spectrometer (DXS) program.

Permanent Civil
Service Workyears

MISSION TO PLANET EARTH..... 1.003

Program activities include activities in land, oceans, and atmospheric sciences. GSFC is engaged in three major types of activities in these areas: research and technology, flight projects, and data analysis.The research and technology effort is directed toward solving major problems involving conceptual instrument design and testing, mission payload studies, and developing flight mission concepts. Mathematical models are designed and constructed to study the global circulation of the atmosphere; the geopotential fields (gravity and magnetic) of the Earth; the processes of the oceans; the physical characteristics of the Earth's vegetation cover, water, and land; and the interaction between the Earth's atmosphere, hydrosphere, and cryosphere.

Flight project responsibilities include operating weather satellite missions for the National Oceanic and Atmospheric Administration (NOAA) and conducting correlation measurements from balloons, sounding rockets, aircraft, and ground installations.

A continuing major thrust is the development of the Earth Observing System (EOS). The primary objective of the Earth Observing System is to record global change and to observe regional-to-global processes . Utilizing several satellites, EOS will document global change over a fifteen year period to provide long-term, consistent data sets for use in modeling and understanding global processes. This process and modeling research effort will provide the basis for establishing predictive global change models for policy makers' and scientists' use in formulating strategies to manage human impacts on global processes such as the greenhouse effect, ozone depletion, and deforestation.

A component of the Mission to Planet Earth concept, managed by GSFC is the Earth Probes program. Earth Probes are an extension of the Explorer concept and are designed to provide a platform for investigations in Earth science requiring special orbital characteristics. As part of the Earth Probe program, GSFC will manage the

development of the Total Ozone Mapping Spectrometer (TOMS). Another Earth Probe is the Tropical Rainfall Mapping Mission (TRMM).

Earth Science data analysis activities involve the formulation, analysis, and distribution of data received from satellites. Data from the Earth Radiation Budget Experiment will continue to be collected for study of geographical and seasonal variations of the Earth's radiation budget.

Management and operation of the Agency's scientific computing and archival facilities will continue. The NASA Center for Computational Services (NCCS) serves the scientific community with its super-computing resources.

ADVANCED CONCEPTS AND TECHNOLOGY..... 48

SPACE RESEARCH AND TECHNOLOGY..... 41

The Space Research and Technology program activities provide advanced technology for future NASA missions while advancing the state-of-the-art in many science and engineering disciplines. The development program encompasses technologies targeted at improved space borne instruments, on-board spacecraft systems and subsystems, and end-to-end systems. In addition, GSFC is involved in flight test and demonstration of the integration of new technology on Space Shuttle and Expendable Launch Vehicle (ELV) systems.

COMMERCIAL PROGRAMS..... 7

This program's two primary goals are to promote and develop private sector investment in space-based technologies and to promote industrial productivity through the transfer to the nation's commercial sector of technologies that derive from NASA's Research and Development (R&D) programs and activities. To achieve its goals, Commercial Programs works to establish innovative partnerships and innovative approaches leading to new commercial enterprises, products, and services.

	Permanent Civil Service Workyear
AERONAUTICAL RESEARCH AND TECHNOLOGY.....	19

The Wallops Flight Facility is used to conduct flight studies of new approach and landing procedures using the latest in guidance equipment and techniques, pilot information displays, human factors data, and terminal area navigation. Flight tests of wind shear detection systems will also be supported.

SAFETY, RELIABILITY AND QUALITY ASSURANCE.....	15

GSFC has responsibility for the Agency's electronic parts standards activity, including preparing and maintaining the NASA Standard Parts List (NSPL); evaluating new parts technology for potential additions to the NSPL; and for preparing qualification criteria to be used by vendors.

TRACKING AND DATA PROGRAMS.....	574

Research and technology involves the investigation and development of advanced systems and techniques for spacecraft communications and tracking, command and control, and data acquisition and processing. The primary objectives are to apply technology and develop advanced capabilities to meet the tracking and data processing requirements of new missions and to improve the cost effectiveness and reliability of flight mission support.

The operational part of the Space Tracking and Data Systems program involves five main areas: operation of the Tracking and Data Relay Satellite System (TDRSS); mission control, data processing, and orbit/attitude computation support; the Space Tracking and Data Network (STDN); the NASA Communications (NASCOM) Network; and the Aeronautics, Balloons and Sounding Rocket Program.

The NASA Communications Network links the stations of the Deep Space Network (DSN), STDN, TDRSS, and other tracking and data acquisition elements with control centers and data processing and computation centers.

Permanent Civil
Service Workyear

CENTER MANAGEMENT AND OPERATIONS SUPPORT..... 711

Center Management and Operations Support - Provides services to all GSFC organizations. The civil service personnel include:

Director and staff - The Center Director, Deputy Director, organization Directors and staff; e. g., Comptroller, Chief Counsel, Personnel Officer, Equal Opportunity Officer, and Public Affairs officer.

Management Support - Provide information and control services supporting all levels of Center management, both program and functional. Specific functions include resources and financial management, contracting and procurement, property management, and management systems and analysis.

Operations Support - Provide for the operation and maintenance of institutional facilities, buildings, systems, and equipment, including those who manage or provide technical services.

		1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)			
I.	PERSONNEL AND RELATED COSTS	242,933	256,800	250,746	259,247
A.	COMPENSATION AND BENEFITS	238,391	247,065	247,592	255,291
1.	COMPENSATION	202,727	208,948	208,536	213,898
2.	BENEFITS	35,664	38,117	39,056	41,393
B.	SUPPORTING COSTS	4,542	9,735	3,154	3,956
1.	TRANSFER OF PERSONNEL	627	1,030	430	641
2.	INVESTIGATIVE SERVICES	0	4,725	40	115
3.	PERSONNEL TRAINING	3,915	3,980	2,684	3,200
II.	TRAVEL	7,056	7,780	7,100	7,064
A.	PROGRAM TRAVEL	5,791	6,447	5,825	5,789
B.	SCIENTIFIC AND TECHNICAL DEVELOPMENT TRAVEL	718	748	720	720
C.	MANAGEMENT AND OPERATIONS TRAVEL	547	585	555	555
	TOTAL, FUND REQUIREMENTS	249,989	264,580	257,846	266,311

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
	(Thousands of Dollars)			
Explanation of Fund Requirements				
I. PERSONNEL AND RELATED COSTS	242,933	256,800	250,746	259,247
A. Compensation and Benefits	238,391	247,065	247,592	255,291
1. Compensation	202,727	208,948	208,536	213,898

The 1993 Current Estimate includes funding for a full year of the 1992 pay raise, the January 1993 pay raise, full year funding for promotions, within grade increases and other personnel actions, offset by Executive Order reductions reductions. The 1994 Budget Estimate reflects a full year of the 1993 pay raise, normal salary growth for personnel actions and the impact of the "Executive Order 12839" FTE reduction.

2. Benefits	35,664	38,117	39,056	41,393

The increase from the 1993 Budget Estimate to the 1993 Current Estimate includes anticipated increases in the FERS retirement program and repricing of health benefits. The 1994 Estimate is due tc full year funding of the 1993 pay raise, increased health and retirement benefits, offset by Executive Order FTE reductions.

B. Supporting Costs	4,542	9,735	3,154	3,956
1. Transfer of Personnel	627	1,030	430	641

The decrease from the 1993 Budget Estimate to the 1993 Current Estimate results from the need to reduce discretionary costs in order to minimize the FTE reductions imposed by the constrained budget. The 1994 Estimate reflects an increase for anticipated new hires eligible for these benefits.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
	(Thousands of Dollars)			
2. Investigative Services	0	4,725	40	115

The 1993 Current Estimate includes the transfer of the security investigation responsibility from Headquarters to the centers and reflects the cancellation of the Project Core conversion program. The 1994 Estimate includes investigations deferred from 1993.

3. Personnel Training	3,915	3,980	2,684	3,200

The purpose of the GSFC's training program is to continue to develop the skills and knowledge of civil service employees in order to more efficiently support center roles and missions. The decrease in the 1993 Current Estimate from the 1993 Budget Estimate is a result of budget constraints. The 1994 Budget Estimate reflects the restoration of training deferred from 1993.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
	(Thousands of Dollars)			

Explanation of Fund Requirements

II.	TRAVEL	7,056	7,780	7,100	7,064
	A. Program Travel	5,791	6,447	5,825	5,789

The decrease in the 1993 Current Estimate incorporates required budget reductions. The 1994 Budget Estimate holds travel to essentially the same levels as 1993.

	B. Scientific and Technical Development Travel	718	748	720	720

The decrease in the 1993 Current Estimate incorporates required budget reductions.

	C. Management and Operations Travel	547	585	555	555

The decrease in the 1993 Current Estimate incorporates required budget reductions.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
GODDARD SPACE FLIGHT CENTER
Greenbelt, Maryland

*ONBOARD AS OF 2/28/93

DIRECTOR
ASSOCIATE DIRECTORS

	93*	93	94
SES	3	3	3
EXCEPTED/ST	0	0	0
GS/GM 18	0	0	0
GS/GM 16	0	0	0
GS/GM 14	0	0	0
OTHER GS/GM	0	0	0
WAGE GRADE	0	0	0
TOTAL	3	3	3

TOTAL		EOY	EOY
	93*	93	94
SES	57	57	57
EXCEPTED/ST	6	13	14
GS/GM 18	0	0	0
GS/GM 16	610	608	606
GS/GM 14	762	760	747
OTHER GS/GM	2660	2667	2608
WAGE GRADE	83	83	83
TOTAL	3837	3848	3808

NASA OFFICE OF INSPECTOR GENERAL/GSFC FIELD OFFICE

CHIEF COUNSEL

	93*	93	94
SES	1	1	1
EXCEPTED/ST	0	0	0
GS/GM 18	0	0	0
GS/GM 16	0	0	0
GS/GM 14	6	6	6
OTHER GS/GM	3	3	3
WAGE GRADE	0	0	0
TOTAL	9	9	9

EQUAL OPPORTUNITY PROGRAMS OFFICE

	93*	93	94
SES	0	0	0
EXCEPTED/ST	0	0	0
GS/GM 18	0	0	0
GS/GM 16	1	1	1
GS/GM 14	0	0	0
OTHER GS/GM	6	6	6
WAGE GRADE	0	0	0
TOTAL	7	7	7

OFFICE OF PUBLIC AFFAIRS

	93*	93	94
SES	0	0	0
EXCEPTED/ST	0	0	0
GS/GM 18	0	0	0
GS/GM 16	1	1	1
GS/GM 14	3	3	3
OTHER GS/GM	13	13	13
WAGE GRADE	0	0	0
TOTAL	17	17	17

OFFICE OF UNIVERSITY PROGRAMS

	93*	93	94
SES	1	1	1
EXCEPTED/ST	0	0	0
GS/GM 18	0	0	0
GS/GM 16	0	0	0
GS/GM 14	1	1	1
OTHER GS/GM	0	0	0
WAGE GRADE	0	0	0
TOTAL	2	2	2

DIRECTOR OF FLIGHT PROJECTS

	93*	93	94
SES	11	11	11
EXCEPTED/ST	0	0	0
GS/GM 18	0	0	0
GS/GM 16	139	137	134
GS/GM 14	147	146	142
OTHER GS/GM	176	181	100
WAGE GRADE	0	0	0
TOTAL	473	474	487

COMPTROLLER

	93*	93	94
SES	1	1	1
EXCEPTED/ST	0	0	0
GS/GM 18	0	0	0
GS/GM 16	3	3	3
GS/GM 14	10	10	19
OTHER GS/GM	91	91	00
WAGE GRADE	0	0	0
TOTAL	105	106	103

DIRECTOR OF FLIGHT ASSURANCE

	93*	93	94
SES	2	2	2
EXCEPTED/ST	0	0	0
GS/GM 18	0	0	0
GS/GM 16	20	20	20
GS/GM 14	39	39	39
OTHER GS/GM	76	76	74
WAGE GRADE	0	0	0
TOTAL	145	146	143

DIRECTOR OF HUMAN RESOURCES

	93*	93	94
SES	1	1	1
EXCEPTED/ST	0	0	0
GS/GM 18	0	0	0
GS/GM 16	0	0	0
GS/GM 14	3	3	3
OTHER GS/GM	71	71	70
WAGE GRADE	0	0	0
TOTAL	75	76	74

DIRECTOR OF MANAGEMENT OPERATIONS

	93*	93	94
SES	3	3	3
EXCEPTED/ST	0	0	0
GS/GM 18	0	0	0
GS/GM 16	19	19	19
GS/GM 14	43	43	43
OTHER GS/GM	462	464	456
WAGE GRADE	83	83	83
TOTAL	580	582	583

DIRECTOR OF MISSION OPERATIONS & DATA SYS

	93*	93	94
SES	0	0	0
EXCEPTED/ST	0	0	0
GS/GM 18	0	0	0
GS/GM 16	89	89	89
GS/GM 14	110	118	118
OTHER GS/GM	468	454	444
WAGE GRADE	0	0	0
TOTAL	646	648	638

DIRECTOR OF SPACE SCIENCES

	93*	93	94
SES	5	5	5
EXCEPTED/ST	3	0	0
GS/GM 18	0	0	0
GS/GM 16	90	88	88
GS/GM 14	77	77	77
OTHER GS/GM	150	153	140
WAGE GRADE	0	0	0
TOTAL	311	312	307

DIRECTOR OF ENGINEERING

	93*	93	94
SES	0	0	0
EXCEPTED/ST	0	1	1
GS/GM 18	0	0	0
GS/GM 16	83	83	83
GS/GM 14	171	171	171
OTHER GS/GM	820	822	800
WAGE GRADE	0	0	0
TOTAL	862	866	871

DIRECTOR OF SUBORBITAL PROJECTS & OPERATIONS

	93*	93	94
SES	4	4	4
EXCEPTED/ST	0	0	0
GS/GM 18	0	0	0
GS/GM 16	18	18	18
GS/GM 14	36	36	36
OTHER GS/GM	198	187	183
WAGE GRADE	0	0	0
TOTAL	251	252	240

DIRECTOR OF EARTH SCIENCES

	93*	93	94
SES	0	0	0
EXCEPTED/ST	2	3	4
GS/GM 18	0	0	0
GS/GM 16	83	83	83
GS/GM 14	102	102	102
OTHER GS/GM	229	230	213
WAGE GRADE	0	0	0
TOTAL	416	418	410

APPROVED_____ DATE _____

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1994 ESTIMATES

AMES RESEARCH CENTER

CENTER ROLES AND MISSIONS

PRINCIPAL ROLES:

Aeronautical Research and Technology - Conduct theoretical, experimental, and flight research in fundamental aerodynamics, high-performance aircraft, rotorcraft, powered-lift technology, low-speed vehicle systems, guidance and control, flight simulation, aircraft automation, and human-vehicle interactions.

Transatmospheric Research and Technology - Conduct research in aeronautics and space disciplines to provide the technology for vehicles capable of flight to orbit and/or hypersonic cruise.

Gravitational Biology and Biomedical Research - Conduct of research to understand the mechanisms by which gravity affects the function and development of living systems, and to develop options for preventing health and psychophysiological problems during and following extended spaceflight.

Advanced Life Support - Develop the physical/chemical and regenerative life support technologies and extravehicular activity systems essential to exploration and extended presence in space.

Exobiology - Conduct research on the origin, evolution, and distribution of life and life-related molecules on Earth and throughout the universe.

Earth System Science - Conduct research, develop airborne and spaceborne instruments, and manage projects in the science of Earth's atmosphere and ecosystems.

Materials and Structures - Conduct tests of thermal protection systems and materials responses to aerodynamic heating with particular emphasis on high-temperature space or hypersonic vehicle structures.

Computational Fluid Dynamics - Definition of new hardware and software systems and application of these systems to aeronautical and other related areas.

Computing and Communications - Conduct research to accelerate the development and application of high performance computing technologies.

Information Sciences - Conduct research on the technological development of intelligent, autonomous systems for support of planetary, astrophysical and aeronautical missions.

Fluid and Thermal Physics - Develop thermal analysis methods and thermal protection systems required for aerospace planes, planetary entry probes, and orbital transfer vehicles.

High Speed Aerodynamics - develop computational tools and experimental techniques for the design of subsonic and supersonic lifting surfaces and the integration of the propulsion systems with airframes.

SUPPORTING ROLES:

Space Transportation System - Provide prime and contingency landing support to the Space Transportation System. Provide critical sustaining engineering services, such as landing simulations, and thermal protection systems.

Airborne Research and Applications - Conduct airborne research and applications experiments.

Physics and Astronomy - Conduct research in infrared astronomy, astrophysics, theoretical studies, and planetary science and atmospheres.

Planetary Exploration - Develop instruments and systems for planetary exploration studies. Conduct mission operations and data analysis support for the Pioneer program and the Galileo atmospheric probe.

DISTRIBUTION OF FULL-TIME EQUIVALENT (FTE) WORKYEARS BY PROGRAM

AMES	FY 1992 ACTUAL	FY 1993 BUDGET ESTIMATE	FY 1993 CURRENT ESTIMATE	FY 1994 BUDGET ESTIMATE
SPACE STATION AND NEW TECHNOLOGY INVESTMENTS	7	10	7	7 *
SPACE FLIGHT PROGRAMS	37	26	24	15
SPACE TRANSPORTATION CAPABILITY DEVELOPMENT	0	0	0	0
SPACE SHUTTLE PRODUCTION AND OPERATIONS	37	26	24	15
LAUNCH SERVICES	0	0	0	0
SPACE SCIENCE	101	120	106	104
PHYSICS AND ASTRONOMY	67	81	77	76
PLANETARY EXPLORATION	34	39	29	28
LIFE SCIENCES/	180	175	166	0
LIFE AND MICROGRAVITY SCIENCES	0	0	0	163
SPACE APPLICATIONS/	90	89	87	0
MISSION TO PLANET EARTH	0	0	0	85
ADVANCED CONCEPTS AND TECHNOLOGY	208	197	195	198
SPACE RESEARCH AND TECHNOLOGY	205	192	192	195
COMMERCIAL PROGRAMS	3	5	3	3
AERONAUTICAL RESEARCH AND TECHNOLOGY	999	1,000	1,002	1,001
TRANSATMOSPHERIC RESEARCH AND TECHNOLOGY	10	10	10	9
SPACE EXPLORATION	0	2	0	0
SAFETY RELIABILITY AND QUALITY ASSURANCE	26	26	32	32
ACADEMIC PROGRAMS	0	0	0	0
TRACKING AND DATA PROGRAMS	27	28	27	27
SUBTOTAL DIRECT	1,685	1,683	1,656	1,641
CENTER MANAGEMENT AND OPERATIONS	571	542	555	544
SUBTOTAL (FULL-TIME PERMANENT)	2,256	2,225	2,211	2,185
OTHER CONTROLLED FTE'S	28	40	31	32
TOTAL, FULL-TIME EQUIVALENTS	2,284	2,265	2,242	2,217
CORE	0	134	0	0
TOTAL, PROGRAM PLAN	2,284	2,399	2,242	2,217

*UNDER REVIEW

PROGRAM DESCRIPTION

	Permanent Civil Service Workyears
SPACE STATION AND NEW TECHNOLOGY INVESTMENTS.....	7

Currently under review.

SPACE FLIGHT PROGRAMS.....	15
SPACE SHUTTLE PRODUCTION AND OPERATIONS.....	15

Dryden Flight Research Facility (DFRF) is one of two primary recovery sites for the Space Shuttle missions. Upon landing, Dryden provides orbiter convoy operations and servicing support and support in mating the orbiter to the Shuttle Carrier Aircraft.

SPACE SCIENCE	104
PHYSICS AND ASTRONOMY.....	76

Provides support for the airborne astronomy program with the C-141 Kuiper Airborne Observatory Aircraft (KAO). This aircraft is operated as a flying astronomical observatory for research conducted by various university teams. Ames Research Center (ARC) manages and operates a variety of other operational aircraft which serve as unique national and international facilities for research.

ARC has an active program in airborne and spaceborne infrared technology. This program utilizes the unique capabilities of infrared astronomy to investigate the nature and evolution of astronomical systems. Definition activity continues for the Stratospheric Observatory for Infrared Astronomy (SOFIA), a future candidate new initiative.

800

Permanent Civil
Service Workyears

PLANETARY EXPLORATION..... 28

Basic research and project management activities in support of solar system exploration are carried out in this program. Project management and scientific support for Pioneers 6 through 11, and the Galileo Probe will continue.

ARC continues an active program of laboratory, computational, and theoretical studies to develop basic atmospheric planetary modeling concepts and obtain the necessary physical data to interpret spacecraft observations of planetary atmospheres and relate these data to the atmosphere of the Earth.

Advanced studies of instrumentation are carried out for potential deployment and on future planetary missions to Mars, Venus, Pluto, comets and asteroids. Astronomical and laboratory studies contribute fundamental data on solar system chemistry and the chemical evolution of planetary atmospheres.

LIFE AND MICROGRAVITY SCIENCES..... 163

Conducts research to understand the effects of space flight on living systems, and understand the origin, evolution, and distribution of life and life-related chemicals on Earth and elsewhere in the universe. ARC also manages non-human biological experiments in space. Research on the effects of gravity on living systems from simple cells to humans will be conducted using spaceflight experiments, ground simulation, and hypergravity facilities.

The Life Support Program manages the integration of work in physical/chemical and regenerative life support systems with the objective of developing closed life support systems so as to reduce dependency on resupply. The Controlled Ecological Life Support System (CELSS) activities will be the focal point for this research. Biospherics research will continue to enhance the understanding of the biological aspects of global conditions and biochemical processes on Earth.

	Permanent Civil Service Workyears
MISSION TO PLANET EARTH.....	85

The atmospheric research program combines the expertise of the Center personnel and university scientists in the development of computer models for the atmosphere and in the measurement of atmospheric constituents and properties from aircraft platforms.

The program of applied research and development to enhance the use of remote and in-situ sensing technology for various Earth resources applications will be continued.

ADVANCED CONCEPTS AND TECHNOLOGY.....	198
SPACE RESEARCH AND TECHNOLOGY.....	195

Basic research focuses on entry technology materials research, aerothermodynamics research, and intelligent systems technology. Focused research supports future space transportation and space science missions, and the definition of advanced technology for space platforms. The Space R&T program includes activities in the areas of spaceborne processors and science sensor technology, development of technologies for humans in space, and robotics and artificial intelligence.

Space Shuttle orbiter experiments are supported to study advanced materials and evaluate possible cost and weight reduction for the thermal protection system for Shuttle and advanced space transportation systems. The infrared astronomy program emphasizes infrared detector research and cryogenics technology. The Space human factors program will continue applied research in space human factors to ensure high levels of productivity and operational safety for future space missions.

Permanent Civil
Service Workyears

COMMERCIAL PROGRAMS..... 3

This program's two primary goals are to promote and develop private sector investment in space-based technologies and to promote industrial productivity through the transfer to the nation's commercial sector of technologies that derive from NASA's Research and Development (R&D) programs and activities. To achieve its goals, Commercial Programs works to establish innovative partnerships and innovative approaches leading to new commercial enterprises, products, and services.

AERONAUTICAL RESEARCH AND TECHNOLOGY..... 1001

The program in aeronautics has three basic elements: generic research and technology, vehicle specific technology, and aeronautical support to other government agencies and to industry. These three elements form a coherent and interdependent program to meet the objectives of providing a technology base for the development of subsonic and high speed transport aircraft, hypersonic aircraft, advanced rotorcraft and powered lift configurations, and the improvement of the operational performance and efficiency of high performance aircraft.

The human factors program will continue basic and applied research in human performance, computational models for human machine visual perception, and development of advanced pilot-vehicle interface concepts to promote the safety and efficiency of aircraft operations.

As part of the Federal High Performance Computing and Communications Program, ARC will lead the computational aeroscience project to develop the necessary computational technology for the numerical simulation of aerospace vehicles in order to optimize design and analyze flight characteristics.

ARC provides 8,000 to 9,000 hours per year of wind tunnel and 5,000 hours per year of vertical Motion Simulator occupancy time in support of both commercial and military aircraft development, as well as support for large NASA projects.

	Permanent Civil Service Workyears
TRANSATMOSPHERIC RESEARCH AND TECHNOLOGY.....	9

Transatmospheric Research and Technology activities focus on developing wind tunnel and flight analysis for use in evaluating the performance of a hypersonic/transatmospheric vehicle.

SAFETY, RELIABILITY, AND QUALITY ASSURANCE.....	32

The Safety, Reliability, and Quality Assurance (SR&QA) function provides support to Center projects. The Safety and Health Office provides institutional safety to the Center and the Reliability and Quality Assurance Office establishes and implements policies and procedures as an component of project development.

TRACKING AND DATA PROGRAMS.....	27

ARC will continue to operate and maintain the NASA Western Aeronautical Test Range proving radar, tracking and data processing, communications, and telemetry for a variety of aeronautical and aerospace programs.

CENTER MANAGEMENT AND OPERATIONS SUPPORT.....	544

Center Management and Operations provides support or services to all ARC organizations which cannot be identified exclusively to a single program or project. The civil service personnel involved are as follows:

Director and Staff - The Center Director, Deputy Director, Associate Directors, and the immediate staff; e.g., Chief Counsel, Patent Counsel, Comptroller, and Directors for Procurement, Equal Opportunity, Public Affairs, and Advanced Space Technology.

Management Support - Provides information and control services supporting all areas of the Center, both program and functional.

Operations Support - Provides for the operation and maintenance of institutional facilities, buildings, systems, equipment, and technical services.

			1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
			(Thousands of Dollars)			
I.	PERSONNEL AND RELATED COSTS		154,023	166,900	158,935	164,332
	A.	COMPENSATION AND BENEFITS	150,511	156,748	156,719	161,014
		1. COMPENSATION	126,993	132,219	131,279	133,525
		2. BENEFITS	23,518	24,529	25,440	27,489
	B.	SUPPORTING COSTS	3,512	10,152	2,216	3,318
		1. TRANSFER OF PERSONNEL	630	240	396	984
		2. INVESTIGATIVE SERVICES	0	7,416	200	206
		3. PERSONNEL TRAINING	2,882	2,496	1,620	2,128
II.	TRAVEL		4,837	5,328	3,941	5,197
	A.	PROGRAM TRAVEL	3,065	3,322	2,508	3,362
	B.	SCIENTIFIC AND TECHNICAL DEVELOPMENT TRAVEL	682	802	527	676
	C.	MANAGEMENT AND OPERATIONS TRAVEL	1,090	1,204	906	1,159
		TOTAL, FUND REQUIREMENTS	158,860	172,228	162,876	169,529

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
	(Thousands of Dollars)			
Explanation of Fund Requirements				
I. PERSONNEL AND RELATED COSTS	154,023	166,900	158,935	164,332
A. Compensation and Benefits	150,511	156,748	156,719	161,014
1. Compensation	126,993	132,219	131,279	133,525

The decrease from the 1993 Budget Estimate to the 1993 Current Estimate is the result of Congressional budget and Executive Order reductions. The 1994 Budget Estimate increase reflects full year funding of the 1993 pay raise, normal salary growth due to promotions, within grades, and merit pay, offset by the "Executive Order 12839" FTE reduction.

2. Benefits	23,518	24,529	25,440	27,489

The increase from the 1993 Budget Estimate to the 1993 Current Estimate is the result of repricing health insurance and retirement program components. The 1994 Budget Estimate increase includes full year funding of the 1993 pay raise, increases to health benefits and retirement costs, offset by Executive Order FTE reductions.

B. Supporting Costs	3,512	10,152	2,216	3,318
1. Transfer of Personnel	630	240	396	984

This supporting costs category includes movement of household goods, subsistence and temporary expenses, real estate costs and miscellaneous moving expenses related to change of duty station. The increase from the 1993 Budget Estimate to the 1993 Current Estimate reflects additional hires eligible for these benefits. The 1994 Budget Estimate increase reflects hires eligible to use relocation services.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
	(Thousands of Dollars)			
2. Investigative Services	0	7,416	200	206

The 1993 Current Estimate includes the transfer of the security investigation responsibility from Headquarters to the centers and reflects the cancellation of the Project Core conversion program. The 1994 Budget Estimate continues this activity at 1993 levels.

3. Personnel Training	2,882	2,496	1,620	2,128

The purpose of the ARC training program is to continue to develop the skills and knowledge of civil service employees in order to more efficiently support center roles and missions. The decrease from the 1993 Budget Estimate to the 1993 Current Estimate is the result of budget constraints. The 1994 Budget Estimate restores training deferred from 1993.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
	(Thousands of Dollars)			
Explanation of Fund Requirements				
II. TRAVEL	4,837	5,328	3,941	5,197
A. Program Travel	3,065	3,322	2,508	3,362

The decrease from the 1993 Budget Estimate to the 1993 Current Estimate is due to budget reductions. The increase from the 1993 Current Estimate to the 1994 Budget Estimate is increased support for major flight programs and includes inflation.

B. Scientific and Technical Development Travel	682	802	527	676

The decrease from the 1993 Budget Estimate to the 1993 Current Estimate is due to budget reductions. The increase between the 1993 Current Estimate and the 1994 Budget Estimate is due to increased participation in research symposia; and provides opportunities to keep the highly technical workforce abreast of "state-of-the-art" technical issues and advancements in the aerospace; scientific; and research and development communities.

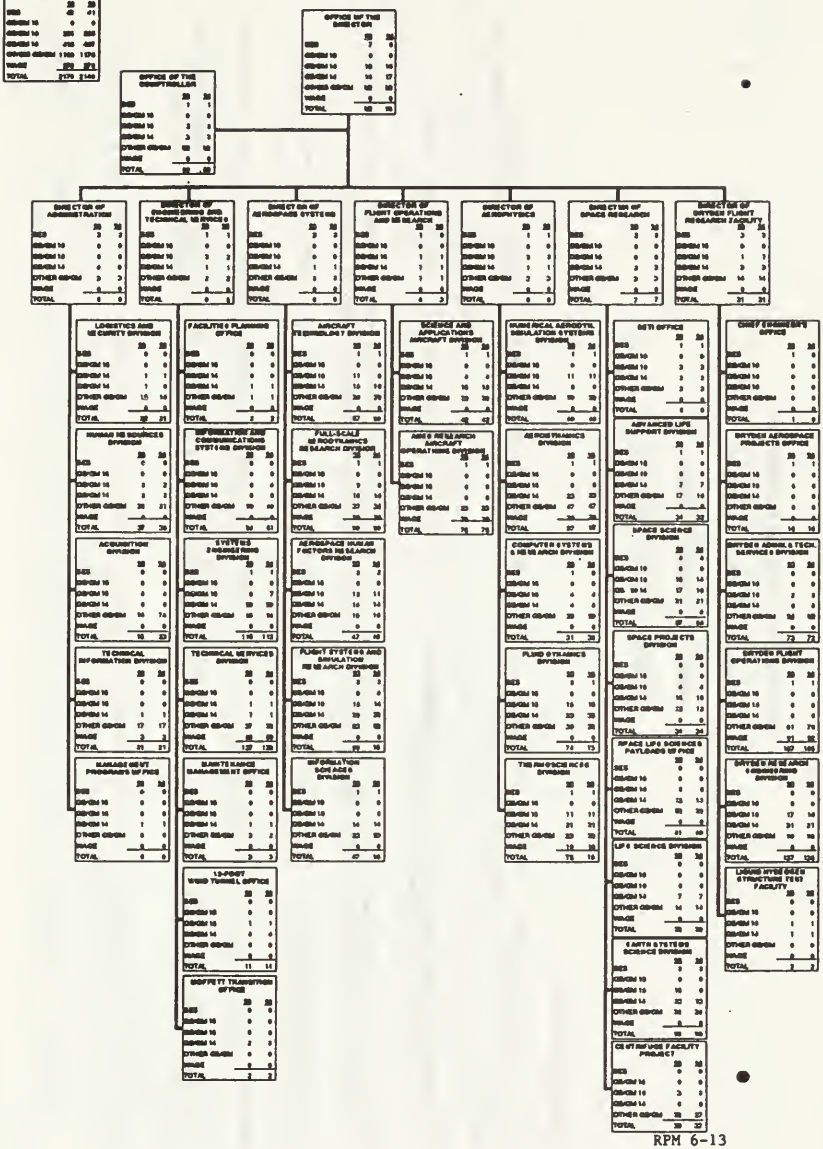
C. Management and Operations Travel	1,090	1,204	906	1,159

The decrease from the 1993 Budget Estimate to the 1993 Current Estimate is due to budget reductions. The increase from the 1993 Current Estimate to the 1994 Budget Estimate is to provide increased functional management oversight and continual improvement reviews.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

AMES RESEARCH CENTER

ORGANIZATION AND STAFFING CHART



RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1994 ESTIMATE

LANGLEY RESEARCH CENTER

CENTER ROLES AND MISSIONS

PRINCIPAL ROLES:

Aeronautical Technology - Conduct advanced research in fundamental aerodynamics; high-speed, highly maneuverable aircraft technology; hypersonic propulsion; guidance and controls; acoustics; and structures and materials.

Transport Aircraft and General Aviation Technology - Develop a technology base for improving transport, general aviation, and commuter aircraft.

Space Transportation Technology - Develop technology for future space transportation systems by analyzing configuration options for a space shuttle replacement system and an Expendable Launch Vehicle.

Space Systems Technology - Perform research to improve operational efficiency and to develop concepts for advanced space systems.

Sensors and Data Acquisition Technology - Develop a technology base for sensors and data acquisition devices.

Information Systems Technology - Develop the technology for highly reliable, fault-tolerant software and data systems for flight critical aerospace vehicle applications and for high performance spaceflight storage systems.

Aero-Space Plane Technology - Combine aeronautics and space disciplines to provide the technology for design of vehicles capable of airbreathing flight from Earth to orbit.

Technology Demonstration Flight Experiments - Define and develop space technology experiments relevant to materials, structures, aerothermodynamics, automated assembly, control and dynamics of space structures; large space antenna assemblies; advanced space transportation systems; and on-orbit assembly and servicing facilities.

SUPPORTING ROLES:

Rotorcraft Technology - Development of the technology base to advance rotorcraft performance.

Atmospheric Sciences - Develop, apply and manage improved techniques for atmospheric sensing.

Earth System Research - Conduct mission analyses, develop sensors, and utilize remote sensing data contributing to model development.

Automation and Robotics - Develop technology for telerobotic and autonomous robotic systems and evaluate application of resulting systems to future space mission needs.

Computational Fluid Dynamics - Develop and apply computational techniques to examine complex, 3D fluid-dynamic phenomena over a wide range of aerodynamic conditions, vehicle configurations, and missions.

Space Radiation Exposure - Conduct research on the interaction of solar and galactic cosmic radiation in order to estimate effects on human exposure.

DISTRIBUTION OF FULL-TIME EQUIVALENT (FTE) WORKYEARS BY PROGRAM

LANGLEY	FY 1992 ACTUAL	FY 1993 BUDGET ESTIMATE	FY 1993 CURRENT ESTIMATE	FY 1994 BUDGET ESTIMATE
SPACE STATION AND NEW TECHNOLOGY INVESTMENTS	22	37	24	24 *
SPACE FLIGHT PROGRAMS	29	15	31	29
SPACE TRANSPORTATION CAPABILITY DEVELOPMENT	20	15	31	29
SPACE SHUTTLE PRODUCTION AND OPERATIONS	9	0	0	0
LAUNCH SERVICES	0	0	0	0
SPACE SCIENCE	1	2	0	0
PHYSICS AND ASTRONOMY	0	0	0	0
PLANETARY EXPLORATION	1	2	0	0
LIFE SCIENCES/	7	9	7	0
LIFE AND MICROGRAVITY SCIENCES	0	0	0	19
SPACE APPLICATIONS/	239	264	218	0
MISSION TO PLANET EARTH	0	0	0	205
ADVANCED CONCEPTS AND TECHNOLOGY	564	536	519	490
SPACE RESEARCH AND TECHNOLOGY	549	521	505	476
COMMERCIAL PROGRAMS	15	15	14	14
AERONAUTICAL RESEARCH AND TECHNOLOGY	1,286	1,271	1,346	1,376
TRANSATMOSPHERIC RESEARCH AND TECHNOLOGY	90	60	56	25
SPACE EXPLORATION	0	3	0	0
SAFETY RELIABILITY AND QUALITY ASSURANCE	6	13	6	8
ACADEMIC PROGRAMS	0	0	0	0
TRACKING AND DATA PROGRAMS	0	0	0	0
SUBTOTAL DIRECT	2,244	2,210	2,207	2,176
CENTER MANAGEMENT AND OPERATIONS	702	715	707	693
SUBTOTAL (FULL-TIME PERMANENT)	2,946	2,925	2,914	2,869
OTHER CONTROLLED FTE'S	16	19	14	19
TOTAL, FULL-TIME EQUIVALENTS	2,962	2,944	2,928	2,888
CORE	0	43	0	0
TOTAL, PROGRAM PLAN	2,962	2,987	2,928	2,888

*UNDER REVIEW

PROGRAM DESCRIPTION

	Permanent Civil Service Workyears
SPACE STATION AND NEW TECHNOLOGY INVESTMENTS.....	24

Currently under review.

SPACE FLIGHT PROGRAMS.....	29
SPACE TRANSPORTATION CAPABILITY DEVELOPMENT.....	29

Research will be conducted on the advanced manned launch system studies which provide the Agency long-range planning for a second generation Space Shuttle anticipated after the year 2000. Continued research is being conducted on the HL-20 Lifting Body Configuration for application to a near-term Personnel Launch System and a Space Station Assured Crew Return Vehicle.

LIFE SCIENCES AND MICROGRAVITY SCIENCES.....	19

The space radiation exposure program supports existing and future manned space efforts in order to more accurately assess astronaut radiation exposures and body shielding factors.

MISSION TO PLANET EARTH.....	205

The space applications program provides a national research capability for understanding the environment and for developing atmospheric sensing systems and techniques. Langley Research Center (LaRC) has been designated a Primary Data and Archival Center for Earth Radiation and Atmospheric Chemistry for the Earth Observing System (EOS). LaRC will continue to study the Earth's atmosphere to assess changes caused by man and to determine whether or not there is any associated change in the chemical composition of the stratosphere that would change the transmission of solar ultraviolet radiation to the Earth's surface.

Permanent Civil
Service Workyears

A significant improvement in the understanding of man's impact on the atmosphere and climate will be obtained from the combination of LaRC developed statistical/theoretical models and the comprehensive global data set provided by present spaceborne sensors. LaRC has the responsibility for data processing and analysis of the Earth Radiation Budget Experiment and the Halogen Occultation Experiment (HALOE).

This program provides basic research in order to establish scientific and engineering bases to evaluate the potential of crystal growth in space for advanced electronic and electro-optical devices.

ADVANCED CONCEPTS AND TECHNOLOGY.....	490
SPACE RESEARCH AND TECHNOLOGY.....	476

The space research and technology program applies multi-discipline expertise to current and future technology requirements. Longer range studies are directed at defining the technology requirements for future space systems and missions. In the Civil Space Technology Initiative (CSTI), LaRC supports the Space Transportation, Operations, Space Platforms and Science thrusts. Mission and system analyses are directed toward the establishment of requirements for future space systems and their supporting infrastructure.

Materials research is conducted to establish and demonstrate the technology of advanced materials in a wide variety of space applications. Environmental effects on the mechanical and physical properties of materials are being studied utilizing specialized facilities and laboratories.

The goal of research in structures is to provide validated analysis and design methodology, design concepts, and dynamics and control methodology required for efficient long-life space transportation and payload structures. Research will be initiated on integrated controls software that will require application of advanced numerical techniques and computer hardware.

Extensive research in electronic component technology, spacecraft guidance and control, large space antenna systems, automation and robotics, sensor technology, and information systems technology is also being

conducted. The Aerothermodynamics Research Program provides an aerodynamic/aeroheating analysis capability via ground-based testing, flight data validation, and CFD analysis which supports the design of efficient future space transportation vehicle concepts.

COMMERCIAL PROGRAMS..... 14

This program's two primary goals are to promote and develop private sector investment in space-based technologies and to promote industrial productivity through the transfer to the nation's commercial sector of technologies that derive from NASA's Research and Development (R&D) programs and activities. To achieve its goals, Commercial Programs works to establish innovative partnerships and innovative approaches leading to new commercial enterprises, products, and services.

AERONAUTICAL RESEARCH AND TECHNOLOGY..... 1,376

The aeronautical research and technology program applies discipline research to current and future technology requirements and demonstrations of technology applications. The aerodynamics activity covers extensive theoretical and experimental activities. Basic work in fluid and flight mechanics involves theoretical and experimental determination of aerodynamic flows and complex aircraft motions.

Critical environmental compatibility issues are studied in order to make decisions on future high speed civil transport technology and development programs. Technology options for realization of practical hypersonic and transatmospheric flight are also being examined.

The materials and structures effort is directed at the development of new and improved structural materials, fabrication processes, and structural design technology to improve the structural efficiency, reliability, and durability.

The research program in computer science is directed at computer networks, concurrent systems design, software engineering, and fault-tolerant software techniques for improved system reliability. Controls and guidance research includes programs to advance technology in aircraft guidance and navigation, aircraft control

Permanent Civil
Service Workyears

systems, cockpit systems integration and interfacing techniques, and performance validation and verification methods. Research continues in aircraft noise prediction and abatement and wind shear avoidance.

TRANSATMOSPHERIC RESEARCH AND TECHNOLOGY..... 25

Activity includes study of supersonic combustion of both ramjets and other advanced airbreathing propulsion systems; advanced materials for high-temperature applications; development of large reusable structures for aerospace vehicles; and studies to define and understand the integration of advanced technologies into a future class of horizontal takeoff and landing vehicles capable of operating to orbit and/or hypersonic cruise within the atmosphere.

SAFETY, RELIABILITY, AND QUALITY ASSURANCE..... 8

The Safety, Reliability, and Quality Assurance program provides independent assessment activities which reduce program risk.

CENTER MANAGEMENT AND OPERATIONS..... 693

Center Management and Operations provides services or support to all LaRC organizations. The civil service personnel involved are:

Director and Staff - The Center Director, Deputy Director, Associate Director, Assistant Director and immediate staff; e.g., Comptroller, Director of Procurement, Equal Opportunity, and External Affairs.

Management Support - Provide information and control services supporting all levels of Center management, both program and functional.

Operations Support - Provide for the operation and maintenance of institutional facilities, buildings, systems, and equipment.

			1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
			(Thousands of Dollars)			
	PERSONNEL AND RELATED COSTS		168,170	174,500	175,709	181,617
	A.	COMPENSATION AND BENEFITS	165,526	169,969	173,847	179,306
		1. COMPENSATION	140,294	143,433	146,280	149,364
		2. BENEFITS	25,232	26,536	27,567	29,942
	B.	SUPPORTING COSTS	2,644	4,531	1,862	2,311
		1. TRANSFER OF PERSONNEL	560	131	219	228
		2. INVESTIGATIVE SERVICES	0	2,350	88	190
		3. PERSONNEL TRAINING	2,084	2,050	1,555	1,893
II.	TRAVEL		4,681	5,165	3,892	5,000
	A.	PROGRAM TRAVEL	2,962	3,562	2,474	3,179
	B.	SCIENTIFIC AND TECHNICAL DEVELOPMENT TRAVEL	1,134	1,113	942	1,210
	C.	MANAGEMENT AND OPERATIONS TRAVEL	585	490	476	611
		TOTAL, FUND REQUIREMENTS	172,851	179,665	179,601	186,617

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
	(Thousands of Dollars)			
Explanation of Fund Requirements				
I. PERSONNEL AND RELATED COSTS	168,170	174,500	175,709	181,617
A. Compensation and Benefits	165,526	169,969	173,847	179,306
1. Compensation	140,294	143,433	146,280	149,364

The increase from the 1993 Budget Estimate to the 1993 Current Estimate is due primarily to the loss of turnover savings. The Current Estimate includes funding for a full year of the 1992 pay raise, the 1993 pay raise, and full year funding for promotions, within grade increases and other personnel actions. The 1994 Budget Estimate reflects full year funding of the 1993 pay raise, normal salary growth for personnel actions, offset by the "Executive Order 12839" FTE reduction.

2. Benefits	25,232	26,536	27,567	29,942

The increase from the 1993 Budget Estimate to the 1993 Current Estimate reflects the calculation of benefits on a much larger salary base as discussed in the compensation area. The 1994 Budget Estimate includes increases for FERS, FICA, Thrift and health benefits, offset by Executive Order FTE reductions.

B. Supporting Costs	2,644	4,531	1,862	2,311
1. Transfer of Personnel	560	131	219	228

This supporting costs category includes movement of household goods, subsistence and temporary expenses, costs associated with purchase and sale of real estate and miscellaneous moving expenses related to change of duty station. The increase from the 1993 Budget Estimate to the 1993 Current Estimate is based on new hires eligible for these benefits. The 1994 Budget Estimate maintains the same level as in 1993.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
	(Thousands of Dollars)			
2. Investigative Services	0	2,350	88	190

The decrease from the 1993 Budget Estimate to the 1993 Current Estimate reflects the cancellation of the Project Core conversion effort and the transfer of the security investigation responsibility from Headquarters. The 1994 Budget Estimate includes delayed 1993 investigations and background checks for new hires in 1994.

3. Personnel Training	2,084	2,050	1,555	1,893

The purpose of the LaRC training program is to continue to develop the skills and knowledge of civil service employees in order to more efficiently support center roles and missions. The decrease from the 1993 Budget Estimate to the 1993 Current Estimate reflects reduced funding due to budget constraints. The 1994 Budget Estimate reflects the restoration of training deferred from 1993.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
	(Thousands of Dollars)			

Explanation of Fund Requirements

II. TRAVEL	4,681	5,165	3,892	5,000
A. Program Travel	2,962	3,562	2,474	3,179

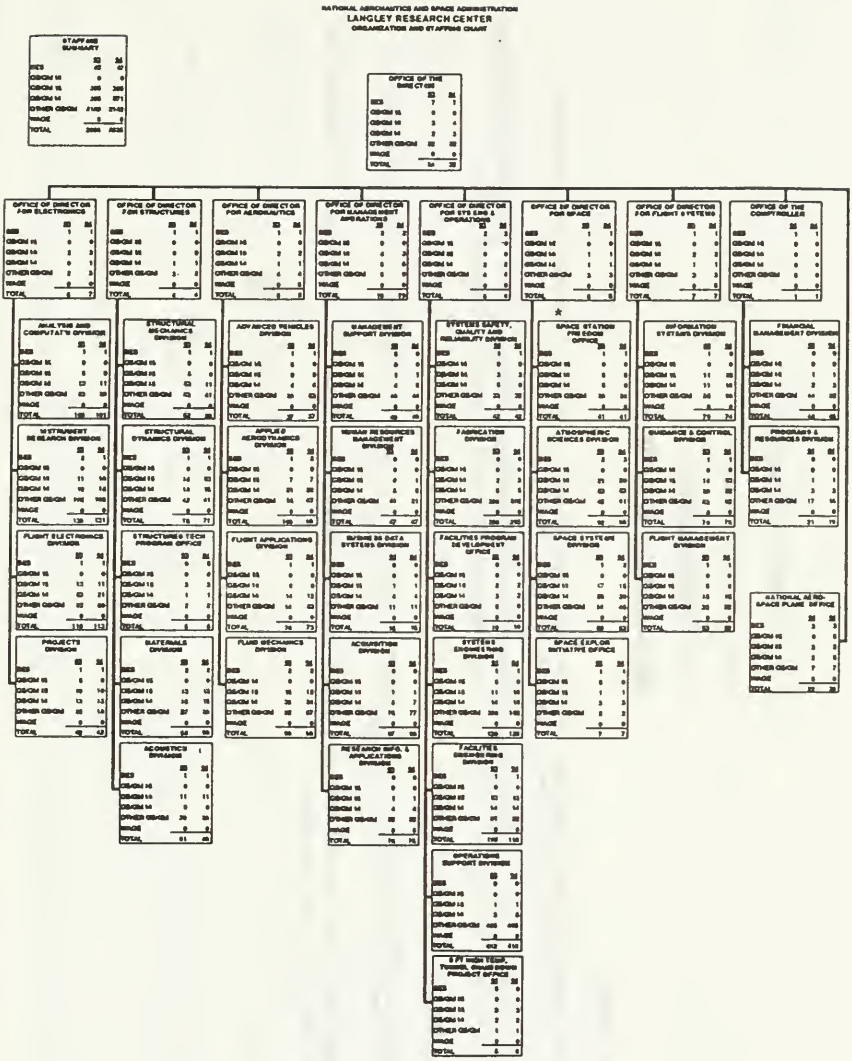
The decrease from the 1993 Budget Estimate to the 1993 Current Estimate is a result of budget reductions. The increase from the 1993 Current Estimate to the 1994 Budget Estimate is to provide support for increased aeronautical program activity.

B. Scientific and Technical Development Travel	1,134	1,113	942	1,210

The decrease from the 1993 Budget Estimate to the 1993 Current Estimate is a result of budget reductions. The increase from the 1993 Current Estimate to the 1994 Budget Estimate is due to increased participation in research symposia; and provides opportunities to keep the highly technical workforce abreast of "state-of-the-art" technical issues and advancements in the aerospace; scientific; and research and development communities.

C. Management and Operations Travel	585	490	476	611

The decrease from the 1993 Budget Estimate to the 1993 Current Estimate is due to budget reductions. The increase from the 1993 Current Estimate to the 1994 Budget Estimate provides support for increased site reviews and management oversight.



* Currently under review.

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1994 ESTIMATES

LEWIS RESEARCH CENTER

CENTER ROLES AND MISSIONS

PRINCIPAL ROLES:

Aeronautical Research and Technology - Conducts aeropropulsion research and technology in fundamental aeropropulsion disciplines and aeronautical propulsion technologies.

Transatmospheric Research and Technology - Conducts aeronautics and space research to provide the technology for a future class of vehicles capable of horizontal takeoff to orbit and/or hypersonic cruise.

Space Station Freedom - UNDER REVIEW

Communications - Develops high-risk technologies required in space communications for future space systems operated by NASA, U.S. industry, and other U.S. government agencies.

Launch Services - Procures and operates intermediate and large class expendable launch vehicle services for NASA and other government agencies.

Space Propulsion Systems Technology - Develops and enhances the technology base for advanced nuclear and electric high and low thrust primary and auxiliary propulsion systems.

Space Energy Processes and Systems Technology - Develop and maintains the technology base for space power and energy conversion systems.

In-Space Flight Experiments - Conducts ground-based and in-space microgravity science experiments in combustion, fluid physics, and materials and also develops flight experiments in the areas of space power, propulsion, and communications technologies.

Commercialization of Space - Promotes the commercialization of space by providing technical support to the Centers for the Commercial Development of Space and by increasing the awareness of U.S. industry of commercial space opportunities.

Technology Transfer - Plans, organizes, and facilitates the transfer of NASA-developed technology to the non-aerospace community.

SUPPORTING ROLES:

Energy Processes and Systems Technology - Manages research and technology projects for terrestrial propulsion systems.

High Performance Computing and Communications - Conducts research to develop necessary computational technology for the numerical simulation of propulsion systems.

DISTRIBUTION OF FULL-TIME EQUIVALENT (FTE) WORKYEARS BY PROGRAM

LEWIS	FY 1992 ACTUAL	FY 1993 BUDGET ESTIMATE	FY 1993 CURRENT ESTIMATE	FY 1994 BUDGET ESTIMATE
SPACE STATION AND NEW TECHNOLOGY INVESTMENTS	374	400	402	402 *
SPACE FLIGHT PROGRAMS	9	60	7	7
SPACE TRANSPORTATION CAPABILITY DEVELOPMENT	4	5	4	4
SPACE SHUTTLE PRODUCTION AND OPERATIONS	5	55	3	3
LAUNCH SERVICES	74	0	72	66
SPACE SCIENCE	0	0	0	0
PHYSICS AND ASTRONOMY	0	0	0	0
PLANETARY EXPLORATION	0	0	0	0
LIFE SCIENCES/	0	0	0	0
LIFE AND MICROGRAVITY SCIENCES	0	0	0	210
SPACE APPLICATIONS/	240	230	264	0
MISSION TO PLANET EARTH	0	0	0	34
ADVANCED CONCEPTS AND TECHNOLOGY	551	573	513	494
SPACE RESEARCH AND TECHNOLOGY	514	550	476	455
COMMERCIAL PROGRAMS	37	23	37	39
AERONAUTICAL RESEARCH AND TECHNOLOGY	924	915	933	965
TRANSATMOSPHERIC RESEARCH AND TECHNOLOGY	21	30	10	10
SPACE EXPLORATION	28	0	0	0
SAFETY RELIABILITY AND QUALITY ASSURANCE	3	2	2	2
ACADEMIC PROGRAMS	0	0	0	0
TRACKING AND DATA PROGRAMS	0	15	0	0
SUBTOTAL DIRECT	2,224	2,225	2,203	2,190
CENTER MANAGEMENT AND OPERATIONS	575	562	554	535
SUBTOTAL (FULL-TIME PERMANENT)	2,799	2,787	2,757	2,725
OTHER CONTROLLED FTE'S	42	44	44	45
TOTAL, FULL-TIME EQUIVALENTS	2,841	2,831	2,801	2,770
CORE	0	81	0	0
TOTAL, PROGRAM PLAN	2,841	2,912	2,801	2,770

*UNDER REVIEW

PROGRAM DESCRIPTION

	Permanent Civil Service Workyears
SPACE STATION AND NEW TECHNOLOGY INVESTMENTS.....	402

Currently under review.

SPACE FLIGHT PROGRAMS.....	7
SPACE TRANSPORTATION CAPABILITY DEVELOPMENT.....	4

Studies are conducted which provide long-range planning for future launch systems and spacecraft.

SPACE SHUTTLE PRODUCTIONS AND OPERATIONS.....	3

Provides technology assessments & technology definition studies for future space operations in the areas of telecommunications and information management networks.

LAUNCH SERVICES.....	66

LeRC is responsible for procurement and management of commercial launch services for the intermediate (Atlas/Centaur and Titan III) and large (Titan IV) class expendable launch vehicles in the NASA Mixed Fleet.

LIFE AND MICROGRAVITY SCIENCES.....	210

Activities consist of microgravity science and applications research; design and development, of space flight experiments; and operation of ground and space flight experiments in materials, combustion, fluid physics, and instrumentation.

Emphasis will continue in advanced design, development, and operation of microgravity experimental flight hardware and ground-based research and flight experiments in basic science and technology associated with materials, combustion, fluid physics phenomena, and power and propulsion technology.

	Permanent Civil Service Workyears
MISSION TO PLANET EARTH	34

LeRC manages operations for the Advanced Communications Technology Satellite.

ADVANCED CONCEPTS AND TECHNOLOGY.....	494
SPACE RESEARCH AND TECHNOLOGY.....	455

The program in space research and technology is coordinated with NASA mission planners to enable and enhance future NASA missions. The research is intended to provide advancements in satellite, platform and planetary power systems; to create new propulsion options for high- and low- thrust systems; to enable new capabilities in space communications and electronics; and to provide effective means to manage cryogenic fluids in microgravity.

The research and technology propulsion program supports the next generation of unmanned launch vehicles, the next generation of government and commercial satellites, and microsatellites and space platforms performing earth observation and exploration.

Space power programs are focused on enhanced micro- and full-size satellite power systems as well as revolutionary capability for deep space and planetary exploration.

The space communications program includes applied research and technology aimed at development of advanced concepts, technologies, and communications systems which meet the needs of NASA missions, Industry and other U.S. government agencies. Emphasis is on developing high data return from NASA missions using less mass and power and developing innovative, new and cost competitive commercial satellite communications services.

Space materials and structures research and technology emphasizes development of improved materials, advancement of structural analysis and life prediction, and development of long-life, reliable space mechanisms.

Permanent Civil
Service Workyears

COMMERCIAL PROGRAMS..... 39

This program's two primary goals are to promote and develop private sector investment in space-based technologies and to promote industrial productivity through the transfer to the nation's commercial sector of technologies that derive from NASA's Research and Development (R&D) programs and activities. To achieve its goals, Commercial Programs works to establish innovative partnerships and innovative approaches leading to new commercial enterprises, products, and services.

AERONAUTICAL RESEARCH AND TECHNOLOGY..... 965

The aeronautical research and technology program provides aerospace propulsion research and technology to enhance the technology base for developing advanced aeronautical propulsion systems in order to increase speed and range; improve fuel efficiency, operating cost, reliability and durability; and decrease environmental impact with respect to reduced emissions and noise.

The generic discipline research includes Internal Computational Fluid Mechanics (ICFM), instrumentation and controls technology, advanced materials, and computational structural mechanics.

Vehicle focused research and technology is directed at developing the propulsion technology for specific engines and propulsion systems. Applications for these focused propulsion systems research efforts include subsonic transports, commuters, supersonic cruise (High Speed Research), hypersonic aircraft, rotorcraft, general aviation, and high performance aircraft.

TRANSATMOSPHERIC RESEARCH AND TECHNOLOGY..... 10

Activities are directed toward understanding and defining a class of airbreathing propulsion systems that are applicable to orbital accelerator and hypersonic cruise vehicles.

	Permanent Civil Service Workyears
SAFETY, RELIABILITY AND QUALITY ASSURANCE.....	2

Will continue to expand the research and technology activities being conducted in areas addressing risk management and SR&QA disciplines.

CENTER MANAGEMENT AND OPERATIONS.....	535

Center Management and Operations Support provides support to all LeRC organizations. The civil service personnel involved are:

Director and Staff - The Center Director, Deputy Director, and immediate staff, e.g., Comptroller, and Directors of Equal Opportunity, External Programs, Chief Counsel, Research Academy and Mission Safety and Assurance.

Management Support - Those who provide information and control services supporting all levels of Center program and functional management.

Operations Support - Those who provide for the operation and maintenance of institutional facilities, buildings, systems, and equipment.

		1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)			
I.	PERSONNEL AND RELATED COSTS	167,945	178,400	174,332	181,088
	A. COMPENSATION AND BENEFITS	165,108	172,793	171,939	179,052
	1. COMPENSATION	138,662	143,963	143,661	148,679
	2. BENEFITS	26,446	28,830	28,278	30,373
	B. SUPPORTING COSTS	2,837	5,607	2,393	2,036
	1. TRANSFER OF PERSONNEL	7	310	80	85
	2. INVESTIGATIVE SERVICES	0	2,575	166	173
	3. PERSONNEL TRAINING	2,830	2,722	2,147	1,778
II.	TRAVEL	4,381	4,738	4,002	4,681
	A. PROGRAM TRAVEL	2,873	3,154	2,659	3,115
	B. SCIENTIFIC AND TECHNICAL DEVELOPMENT TRAVEL	711	812	668	775
	C. MANAGEMENT AND OPERATIONS TRAVEL	797	772	675	791
	TOTAL, FUND REQUIREMENTS	172,326	183,138	178,334	185,769

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
	(Thousands of Dollars)			

Explanation of Fund Requirements

I. PERSONNEL AND RELATED COSTS	167,945	178,400	174,332	181,088
A. Compensation and Benefits	165,108	172,793	171,939	179,052
1. Compensation	138,662	143,963	143,661	148,679

The decrease in the 1993 Current Estimate from the 1993 Budget Estimate reflects Congressional budget and Executive Order reductions. The 1994 Budget Estimate includes full year funding of the 1993 pay raise, normal salary growth for promotions, within grades and merit pay, offset by the "Executive Order 12839" FTE reduction.

2. Benefits	26,446	28,830	28,278	30,373

The decrease from the 1993 Budget Estimate to the 1993 Current Estimate is due to a reduction in hiring caused by funding limitations and repricing of health benefits. The 1994 Budget Estimate increase reflects full year funding of the 1993 pay raise, increases in retirement benefit costs and health insurance, offset by Executive Order FTE reductions.

B. Supporting Costs	2,837	5,607	2,393	2,036
1. Transfer of Personnel	7	310	80	85

The decrease in the 1993 Budget Estimate to the 1993 Current Estimate is based on a hiring plan which indicates fewer hires eligible for these benefits. The 1993 and 1994 Budget is based on the hiring of co-op conversions.

2. Investigative Services	0	2,575	166	173

The 1993 Current Estimate reflects a decrease from the 1993 Budget Estimate, resulting from the elimination of

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
	(Thousands of Dollars)			

the core conversions and the transfer of the security investigation responsibility from Headquarters to the centers. The 1994 Budget Estimate maintains the 1993 level of investigations.

3. Personnel Training	2,830	2,722	2,147	1,778

The purpose of the LeRC training program is to continue to develop the skills and knowledge of civil service employees in order to more efficiently support center roles and missions. The 1993 Current Estimate reflects a decrease due to budget constraints. The 1994 Budget Estimate reflects a decrease due to budget constraints.

68-968 O—93——27

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
	(Thousands of Dollars)			

Explanation of Fund Requirements

II. TRAVEL	4,381	4,738	4,002	4,681
A. Program Travel	2,873	3,154	2,659	3,115

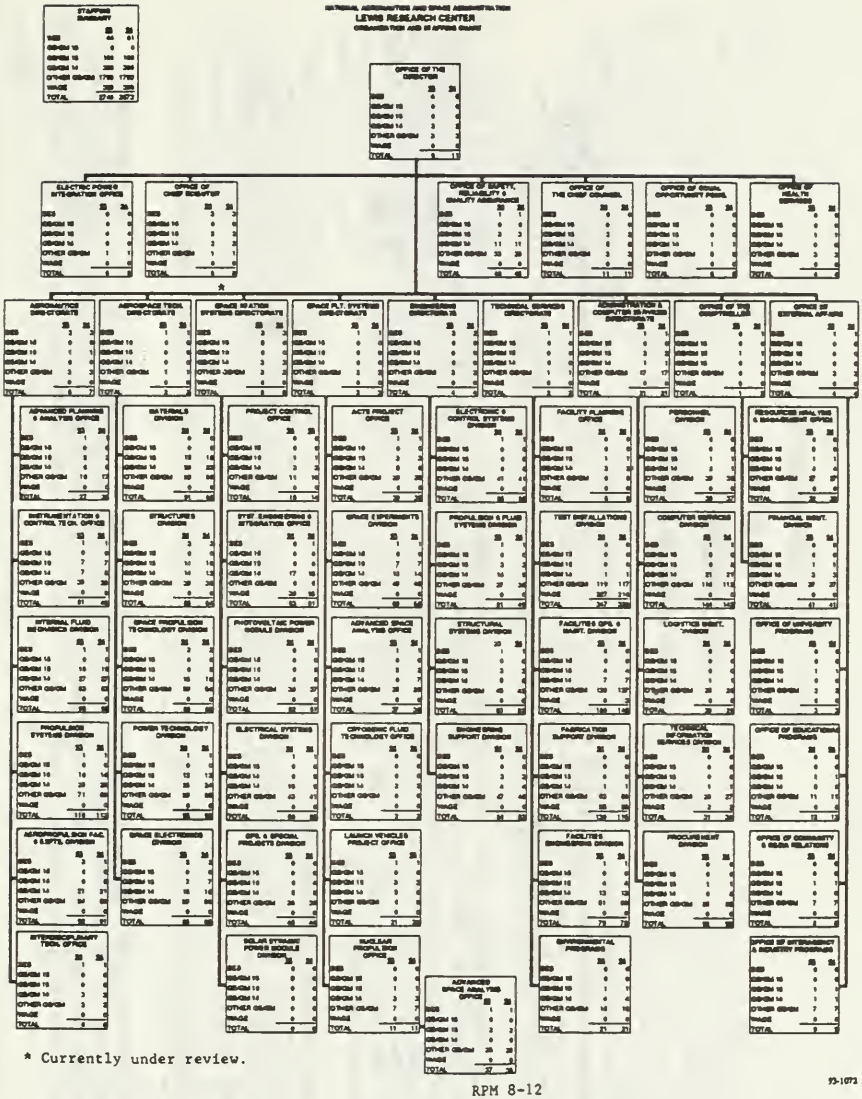
The decrease from the 1993 Budget Estimate to the 1993 Current Estimate is due to required budget reductions. The increase from the 1993 Current Estimate to the 1994 Budget Estimate is to support research experiments in conjunction with shuttle activities.

B. Scientific and Technical Development Travel	711	812	668	775

Tha decrease from the 1993 Budget Estimate to the 1993 Current Estimate is due to required budget reductions. The increase from the 1993 Current Estimate to the 1994 Budget Estimate is due to increased participation in research symposia; and provides opportunities to keep the highly technical workforce abreast of "state-of-the-art" technical issues and advancements in the aerospace; scientific; and research and development communities.

C. Management and Operations Travel	797	772	675	791

The decrease from the 1993 Budget Estimate to the 1993 Current Estimate is due to required budget reductions. The increase from the 1993 Current Estimate to the 1994 Budget Estimate provides continued functional management oversight and review activities.


NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
LEWIS RESEARCH CENTER
ORGANIZATION AND STAFFING CHART
STAFFING SUMMARY
OFFICE OF THE DIRECTOR
ELECTRIC POWER SYSTEMS DIRECTORATE
OFFICE OF CHIEF SCIENTIST
OFFICE OF DEPUTY, RELIABILITY & QUALITY ASSURANCE
OFFICE OF THE CHIEF COUNSEL
OFFICE OF EQUAL OPPORTUNITY PROG.
OFFICE OF HEALTH SERVICES
AERONAUTICS DIRECTORATE
AEROSPACE TECH. DIRECTORATE
SPACE NATION SYSTEMS DIRECTORATE
SPACE FLT. SYSTEMS DIRECTORATE
ENGINEERING DIRECTOR TO
TECHNICAL SERVICES DIRECTORATE
ADMINISTRATION & COMPUTER SERVICES DIRECTORATE
OFFICE OF THE COMPTROLLER
OFFICE OF EXTERNAL AFFAIRS
ADVANCED PLANNING & ANALYSIS OFFICE
MATERIALS DIVISION
PROJECT CONTROL OFFICE
ACTS PROJECT OFFICE
ELECTRONIC & CONTROL SYSTEMS DIVISION
FACILITY PLANNING OFFICE
PERSONNEL DIVISION
RESOURCES ANALYSIS & MANAGEMENT OFFICE
INSTRUMENTATION & CONTROL TECH. OFFICE
STRUCTURES DIVISION
SYST. ENGINEERING & INTEGRATION OFFICE
SPACE EXPERIMENTS DIVISION
PROPULSION & FLUID SYSTEMS DIVISION
TEST INSTALLATIONS DIVISION
COMPUTER SERVICES DIVISION
FINANCIAL MGMT. DIVISION
INTERNAL FLUID MECHANICS DIVISION
SPACE PROPULSION TECHNOLOGY DIVISION
PHOTOVOLTAIC POWER SIGNALS DIVISION
ADVANCED SPACE ANALYSIS OFFICE
STRUCTURAL SYSTEMS DIVISION
FACILITIES OPS. & MAINT. DIVISION
LOGISTICS MGMT. DIVISION
OFFICE OF UNIVERSITY PROGRAMS
PROPULSION SYSTEMS DIVISION
POWER TECHNOLOGY DIVISION
ELECTRICAL SYSTEMS DIVISION
CRYOGENIC FLUID TECHNOLOGY OFFICE
ENGINE BRING SUPPORT DIVISION
FABRICATION SUPPORT DIVISION
TECHNICAL INFORMATION SERVICES DIVISION
OFFICE OF EDUCATIONAL PROGRAMS
AEROSPACE PROP. FAC. & EXPTL. DIVISION
SPACE ELECTRONICS DIVISION
OPN. & SPECIAL PROJECTS DIVISION
LAUNCH VEHICLES PROJECT OFFICE
FACILITIES ENGINEERING DIVISION
PROCUREMENT DIVISION
OFFICE OF COMMUNITY & INDUS. RELATIONS
INTERDISCIPLINARY TECH. OFFICE
SOLAR DYNAMIC POWER MODULE DIVISION
NUCLEAR PROPULSION OFFICE
ENVIRONMENTAL PROGRAMS
OFFICE OF INTERAGENCY & INDUSTRY PROGRAMS
ADVANCED SPACE ANALYSIS OFFICE
TOTAL
* Currently under review.
73-1072

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1994 ESTIMATES

NASA HEADQUARTERS

CENTER ROLES AND MISSIONS

The mission of Headquarters is to plan and provide executive direction for the implementation of U.S. space and aeronautics programs consistent with the objectives stated in the National Aeronautics and Space Act of 1958, as amended. Responsibilities include providing a balanced Agency workforce capable of planning, formulating, and advocating executive direction to national programs to implement the above objectives. The following offices at Headquarters assist in carrying out the technical aspects of the mission:

Office of Space Flight - Plans, directs, executes, and evaluates the acquisition and operations of space flight programs including the Space Shuttle and other space flight related programs. The Space Shuttle is a key element of the National Space Transportation System. The Office of Space Flight develops and implements policy for all system users who interface with the Shuttle; promotes improvements in safety, reliability, and effectiveness of Shuttle operational performance; and manages a variety of programs such as Spacelab, Payload Operations and Support Equipment, the Engineering Technical Base at the OSF centers, and Space Station operations planning.

Office of Space Systems Development - Plans, directs, executes, and evaluates the research and development of space systems, as well as the design, development, test, evaluation, and overall management of the Space Station program. Other functions include the Advanced Programs which conduct definition studies to support future new development programs, systems improvements, and expanded capabilities for space transportation systems.

Space Station Program Office - The Space Station Program Office's primary functions consist of day-to-day program management, development, and implementation.

Office of Space Science (OSS) - Responsible for research and development efforts utilizing a variety of flight system and ground based observatories to increase knowledge of the universe. OSS research and development activities are carried out through the following program areas: Planetary Exploration, Astrophysics, and Space Physics. The Planetary Exploration program encompasses the scientific exploration of

the solar system including the planets and their satellites, comets and asteroids, and the interplanetary medium. The Astrophysics program studies the distant galaxies and the interstellar medium in our galaxy. The Space Physics program studies our own sun providing answers to questions requiring comprehensive research into solar-terrestrial processes and the physics and coupling between the solar wind, magnetosphere, ionosphere, and atmosphere. Responsibilities also include the procurement of Expendable Launch Vehicle Services for NASA and other civil government programs.

Office of Mission to Planet Earth (OMTPE) - Responsible for research and development efforts utilizing a variety of flight system and ground based observatories to increase knowledge of the processes in the atmosphere, oceans, land surface and interior of the Earth, and to advance our knowledge of the interactions between these environments. The Mission to Planet Earth program provides space observations of parameters involved in these processes and extends the national capability to predict environmental phenomena, both short and long-term, and their interactions with human activities. The Mission to Planet Earth program also supports a broad interdisciplinary basic research program.

Office of Life and Microgravity Sciences and Applications (OLMSA) - Responsible for research and development efforts utilizing a variety of flight system and ground based observatories to increase knowledge in Life and Microgravity Sciences. The Life Sciences research program results are applied to maintaining astronaut health and productivity; understanding the response of biological mechanisms to weightlessness; study of basic cellular, development and physiological processes; development of environmental health requirements and support systems for long-term piloted space flight. The Microgravity Research program is aimed at utilizing the low gravity environment to obtain new knowledge and understanding of those physical phenomena made obscure by the effects of gravity and to increase understanding of those physical phenomena made obscure by the effects of gravity and to increase understanding of gravity-dependent phenomena. Responsibilities also include the Shuttle/Spacelab and attached payload mission management activities.

Office of Aeronautics - Plans, directs, executes, and evaluates the aeronautical and transatmospheric research and technology programs. The goal of the aeronautical programs is to conduct research and develop technology to strengthen U.S. leadership in civil and military aviation. The program is based on a strong commitment to develop a broad technology base in support of the aviation industry, to enhance safety and capacity of the national airspace system, and to assure U.S. aviation superiority for national security. The Transatmospheric Research and Technology program is a portion of the joint NASA/Department of Defense National Aerospace Plane (NASP) program. The NASP program objective is to develop and then demonstrate in an experimental flight vehicle the technology required to permit the nation to develop reusable, single-stage-to-

orbit vehicles with airbreathing primary propulsion, and horizontal takeoff and landing capability.

Office of Advanced Concepts and Technology (OACT) - The Office of Commercial Programs and the Space Technology Directorate of the former Office of Aeronautics and Space Technology were merged to create the Office of Advanced Concepts and Technology. OACT will be the NASA focal point for technology innovation and transfer. The new office will support the development and application of technologies critical to the economic, scientific, and technological competitiveness of the U. S. and will promote U. S. industrial preeminence through strengthened linkages between the private sector and NASA technology efforts. OACT activities pursue the transfer of technology from NASA to the private sector, enhanced partnerships between the private sector and NASA, and development of critical technologies essential to the accomplishment of future missions.

Office of Space Communications - Provides the vital tracking, telemetry, command, data acquisition, communications, and data processing required by all NASA flight projects. Included in Earth orbital activities are the Space Transportation System (STS), Spacelab, and scientific and applications missions. The various capabilities provided include: (a) tracking to determine the position and trajectory of vehicles in space; (b) acquisition of science and space applications data from on-board experiments and sensors; (c) acquisition of engineering data on the performance of spacecraft and launch vehicle systems; (d) reception of television transmissions from space vehicles; (e) transmissions of commands from ground facilities to the spacecraft; (f) voice communications with astronauts; (g) transfer of information between the various ground facilities and control centers; and (h) processing of data acquired form the launch vehicles and spacecraft. These capabilities are essential for operating and maintaining U.S. space assets to achieve the scientific objectives of all flight missions and for executing the critical decisions necessary to the success of these missions.

Office of Safety and Mission Quality (OSMQ) - Assures NASA mission safety through the development, implementation, and oversight of uniform safety, reliability, maintainability, technical standards, improving program assurance, and quality assurance (SRM&QA) policies and procedures. OSMQ conducts independent technical assessments of all major flight and nonflight projects to determine compliance to SRM&QA requirements.

CENTER MANAGEMENT AND OPERATIONS - This category is composed of two major groups of Headquarters employees. The first group includes all the functional and staff offices which provide Agency-wide guidance and oversight in areas such as, procurement, personnel, financial management, supply and logistics, equal opportunity, international relations, management systems and facilities.

This second major group includes the employees whose primary task is to provide direct support to the Headquarters staff by providing day-to-day operations in procurement, personnel, financial, and other administrative functions.

DISTRIBUTION OF FULL-TIME EQUIVALENT (FTE) WORKYEARS BY PROGRAM

HEADQUARTERS	FY 1992 ACTUAL	FY 1993 BUDGET ESTIMATE	FY 1993 CURRENT ESTIMATE	FY 1994 BUDGET ESTIMATE
SPACE STATION AND NEW TECHNOLOGY INVESTMENTS	275	285	270	270 *
SPACE FLIGHT PROGRAMS	198	208	197	197
SPACE TRANSPORTATION CAPABILITY DEVELOPMENT	40	41	40	40
SPACE SHUTTLE PRODUCTION AND OPERATIONS	158	167	157	157
LAUNCH SERVICES	7	0	6	6
SPACE SCIENCE	103	97	110	125
PHYSICS AND ASTRONOMY	69	64	76	76
PLANETARY EXPLORATION	34	33	34	49
LIFE SCIENCES/	26	27	34	0
LIFE AND MICROGRAVITY SCIENCES	0	0	0	34
SPACE APPLICATIONS/	99	125	100	0
MISSION TO PLANET EARTH	0	0	0	100
ADVANCED CONCEPTS AND TECHNOLOGY	107	112	105	105
SPACE RESEARCH AND TECHNOLOGY	61	66	61	61
COMMERCIAL PROGRAMS	46	46	44	44
AERONAUTICAL RESEARCH AND TECHNOLOGY	67	69	67	67
TRANSATMOSPHERIC RESEARCH AND TECHNOLOGY	6	6	6	6
SPACE EXPLORATION	16	15	15	0
SAFETY RELIABILITY AND QUALITY ASSURANCE	73	90	74	74
ACADEMIC PROGRAMS	26	26	33	33
TRACKING AND DATA PROGRAMS	59	61	57	57
SUBTOTAL DIRECT	1,064	1,123	1,074	1,074
CENTER MANAGEMENT AND OPERATIONS	868	883	860	850
SUBTOTAL (FULL-TIME PERMANENT)	1,932	2,006	1,934	1,924
OTHER CONTROLLED FTE'S	97	85	68	66
TOTAL, FULL-TIME EQUIVALENTS	2,029	2,091	2,002	1,990
CORE	0	107	0	0
TOTAL, PROGRAM PLAN	2,029	2,198	2,002	1,990

*UNDER REVIEW

		1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)			
I.	PERSONNEL AND RELATED COSTS	163,368	174,500	160,784	167,319
	A. COMPENSATION AND BENEFITS	148,354	158,125	154,711	156,588
	1. COMPENSATION	128,111	134,069	131,328	132,769
	2. BENEFITS	20,243	24,056	23,383	23,819
	B. SUPPORTING COSTS	15,014	16,375	6,073	10,731
	1. TRANSFER OF PERSONNEL	2,196	1,573	1,021	1,387
	2. INVESTIGATIVE SERVICES	3,406	8,756	988	1,296
	3. PERSONNEL TRAINING	9,412	6,046	4,064	8,048
II.	TRAVEL	11,133	12,603	10,686	11,686
	A. PROGRAM TRAVEL	4,877	6,376	4,858	5,441
	B. SCIENTIFIC AND TECHNICAL DEVELOPMENT TRAVEL	1,158	1,050	1,151	1,297
	C. MANAGEMENT AND OPERATIONS TRAVEL	5,098	5,177	4,677	4,948
	TOTAL, FUND REQUIREMENTS	174,501	187,103	171,470	179,005

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
	(Thousands of Dollars)			

Explanation of Fund Requirements

I. PERSONNEL AND RELATED COSTS	163,368	174,500	160,784	167,319
A. Compensation and Benefits	148,354	158,125	154,711	156,588
1. Compensation	128,111	134,069	131,328	132,769

The change in compensation from the 1993 Budget Estimate to the 1993 Current Estimate reflects Congressional reductions, the transferring of functions/positions to the other NASA centers and the impact of Executive Order reductions. The 1994 Budget Estimate includes full year funding of the 1993 pay raise, normal salary growth due to promotions, within grades, merit pay, and the impact of the "Executive Order 12839" FTE reduction.

2. Benefits	20,243	24,056	23,383	23,819

The changes from the 1993 Budget Estimate to the 1993 Current Estimate reflects a decrease in the number of FTE funded at Headquarters and revised rate estimates. The 1994 Budget Estimate includes full year funding of the 1993 pay raise, increases in retirement benefits, and health insurance.

B. Supporting Costs	15,014	16,375	6,073	10,731
1. Transfer of Personnel	2,196	1,573	1,021	1,387

These are the costs associated with transfer of government personnel from other duty stations to NASA Headquarters. The decrease from the 1993 Budget Estimate to the 1993 Current Estimate is due to a reduction in the number of hires using relocation services. The 1994 Budget Estimate includes funding for additional hires to use these benefits.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
	(Thousands of Dollars)			
2. Investigative Services	3,406	8,756	988	1,296

On behalf of the entire Agency, Headquarters reimburses the Federal Bureau of Investigation (FBI), Defense Investigative Services (DIS), Immigration and Naturalization (INS), and Credit Bureau Investigations (CBI) for background checks of new hires and re-investigations of current employees and the costs related to the processing of Equal Employment Opportunity complaint investigations. The cost of investigations is a function of two variables: the number of investigations to be conducted, and the unit charge made by the investigative agencies. The decrease from the 1993 Budget Estimate to the 1993 Current Estimate is due to the cancellation of Core conversions and the decentralization of the agency's OPM investigative costs to each of the centers. The 1994 Budget Estimate includes increases to these services from the agencies performing the investigations.

3. Personnel Training	9,412	6,046	4,064	8,048

The purpose of the Headquarters training program is to continue to develop the skills and knowledge of civil service employees in order to efficiently support center roles and missions. Headquarters responsibilities includes: management, oversight and guidance of agencywide programs; and activities designated and developed specifically for Headquarters personnel. Training costs include tuition, fees and related costs for training at colleges, universities, technical institutions, and for the cost of seminars and workshops. The decrease from the 1993 Budget Estimate to the 1993 Current Estimate is based on budget constraints. The 1994 Budget Estimate provides for some agencywide Total Quality Management training programs and return to a normal level of training in Headquarters and other agencywide programs.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
	(Thousands of Dollars)			

Explanation of Fund Requirements

II. TRAVEL	11,133	12,603	10,686	11,686
A. Program Travel	4,877	6,376	4,858	5,441

The decrease from the 1993 Budget Estimate to the 1993 Current Estimate is reflective of budget reductions. The increase from the 1993 Current Estimate to the 1994 Budget Estimate reflects increased program requirements and inflationary growth.

B. Scientific and Technical Development Travel	1,158	1,050	1,151	1,297

The increase between the 1993 Budget Estimate and the 1993 Current Estimate reflects maintenance of the 1992 level of support to this activity. The increase from the 1993 Current Estimate to the 1994 Budget Estimate is due to increased participation in research symposia; and provides opportunities to keep the highly technical workforce abreast of "state-of-the-art" technical issues and advancements in the aerospace; scientific; and research and development communities.

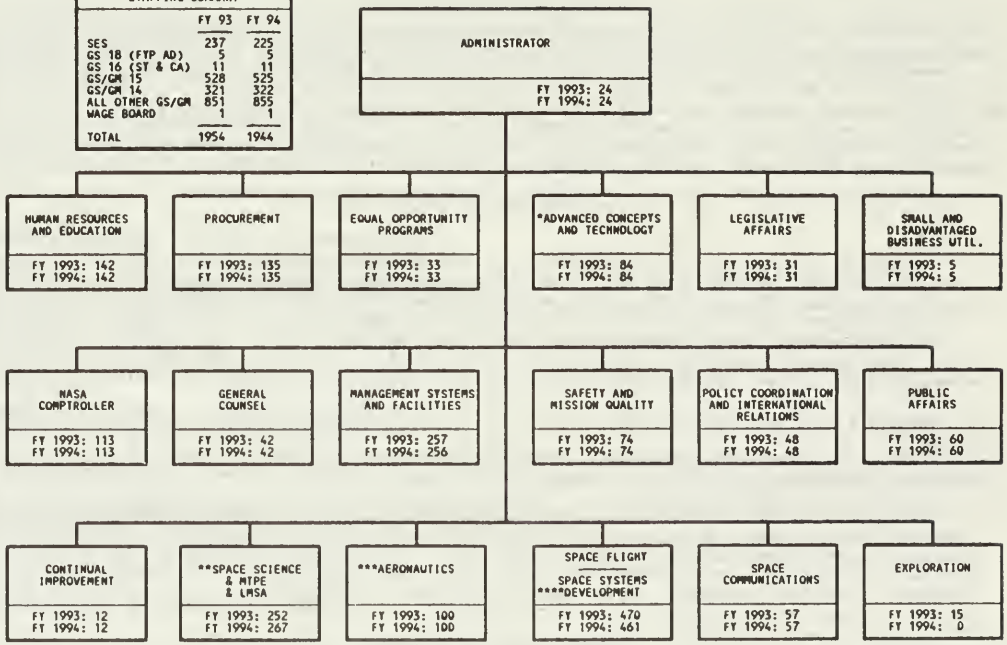
C. Management and Operations Travel	5,098	5,177	4,677	4,948

The decrease from the 1993 Budget Estimate to the 1993 Current Estimate reflects efforts to transfer the funding for the fare subsidy program to benefits. The increase from the 1993 Current Estimate to the 1994 Budget Estimate is primarily inflation, and provides for continued management oversight reviews.

ORGANIZATION AND STAFFING
NASA HEADQUARTERS

HEADQUARTERS STAFFING SUMMARY

	FY 93	FY 94
SES	237	225
GS 18 (FYP AD)	5	5
GS 16 (ST & CA)	11	11
GS/GM 15	528	525
GS/GM 14	321	322
ALL OTHER GS/GM	851	855
WAGE BOARD	1	1
TOTAL	1954	1944



NOTE: * FORMER OFFICE OF COMMERCIAL PROGRAMS REORGANIZED INTO ADVANCED CONCEPTS & TECHNOLOGY.
** FORMER OFFICE OF SPACE SCIENCE & APPLICATIONS REORGANIZED INTO THREE OFFICES; SPACE SCIENCE, MISSION TO PLANET EARTH AND LIFE & MICROGRAVITY SCIENCE AND APPLICATIONS.
*** FORMER OFFICE OF AERONAUTICS & SPACE TECHNOLOGY REORGANIZED INTO AERONAUTICS.
**** OFFICE OF SPACE SYSTEMS DEVELOPMENT CURRENTLY UNDER REVIEW.
NOTE: DATA REPRESENTS ESTIMATED PAID ON-BOARD EMPLOYEES AT END OF FISCAL YEAR.

FMM/03/19/93

INSPECTOR GENERAL

FISCAL YEAR 1994 ESTIMATES

OFFICE OF INSPECTOR GENERAL

BASIS FOR FY 1994 ESTIMATE

The NASA Office of Inspector General (OIG) will continue to effectively perform its mission with 210 Full Time Equivalents (FTEs). At this staffing level, the OIG audit and investigative programs are especially challenged to become more effective and productive. Within this staffing level, the OIG will continue to provide assistance to NASA management and perform its required audit of NASA's financial systems used to prepare financial statements required by the Chief Financial Officers (CFO) Act. This staffing estimate recognizes the budget constraints facing the Agency and the need to do more with less.

As NASA sets new priorities for its programs and operations within current budget constraints, the OIG will be forced to do likewise. The OIG will continue to selectively concentrate staff resources on those programs and operations identified as the most critical and vulnerable to fraud and abuse based on funding levels, program needs, Congressional/Administration concerns and results of OIG research and findings.

Audits will continue to evaluate NASA's financial management practices, systems, controls, and statements to fulfill CFO audit requirements, as well as programmatic and operational vulnerabilities. The OIG investigations program will remain focused on complex white collar criminal cases - fraud against the Government by contractor and government employees, product substitution, false claims, false statements, wire fraud, and conspiracy - which normally demand staff commitments for extended periods. Historically, these criminal cases have represented approximately 85 percent of the total caseload. In addition, the noncriminal caseload includes procurement irregularities, unethical and improper conduct, prohibited personnel practices, and waste and mismanagement.

OBJECTIVES AND STATUS

The OIG audit workload is defined within a structured internal audit universe encompassing NASA's programs and operations and an external universe comprised of NASA's prime contractors, their subcontractors, and grantees, and legislation requiring OIG audit of NASA's financial systems, controls and reports. Ideally each universe should provide audit coverage on a five year cycle. At the FY 1993 audit staffing level, the OIG is operating on an inadequate 16.3 year internal audit cycle. The OIG audit program sets priorities for internal and external audits to maximize the return on available audit resources. These priorities are established and contained in various long range audit plans used to develop the required annual audit plan. This overwhelming audit workload requires continuous adjustment of priorities to provide balanced coverage

of programs and operations most vulnerable to abuse and mismanagement. Further, program/project change, growth, delay and termination increases the need for OIG oversight of contractor/sub-contractor/grantee cost, schedule and performance effectiveness. NASA's continued reliance on contractors and grantees (about 90 percent of the Agency's total obligations are for procurement) requires direct OIG audit work and oversight of Defense Contract Audit Agency (DCAA) audit results to ensure effective contract execution and administration. NASA was billed approximately $17 million during FY 1992 for contract audit services.

The OIG will continue to monitor and assess NASA's high risk areas, material weaknesses and areas of significant concern to ensure that corrective actions are implemented timely. Areas of emphasis will include: institutional support contracting; procurement and contract/subcontract management; information resource management; computer security; product integrity and quality; safety; financial management systems, controls and reports; environmental management; critical sources of supply for programs and missions, facilities infrastructure; and programs/projects being delayed, restructured or terminated because of funding and budget constraints.

Vulnerabilities are determined by taking into consideration the following: whether program/project objectives are accomplished in the most cost-effective manner; if NASA's more than $1 billion annual expenditure on information technology is providing expected programmatic and financial information needed to make sound decisions (NASA is the top ranked civilian agency in information technology spending); management's actions to correct internal control weaknesses reported under the Federal Manager's Financial Integrity Act; improvements in financial management systems, practices, controls and information; effectiveness of the audit follow-up system in enabling management to maintain the status of corrective actions; completeness of safety and mission quality activities; and the adequacy of agencywide corrective actions addressing environmental concerns.

The OIG investigative workload of both criminal and noncriminal cases continues to exceed the availability of investigative resources. Growth in the investigative program has caused OIG primarily to be reactive with emphasis given to the more serious criminal allegations. The FY 1993 investigative staffing level does not allow flexibility to effectively respond to an increasingly complex workload. With the number of complex fraud cases continuing to increase, such cases take longer to resolve, further reducing our flexibility to improve and expand the program. Also, the increasing quantity of investigative allegations received requires a preliminary evaluation to determine their potential impact and, if serious, opening an investigation; further adversely affecting the timely completion of on-going cases.

In summary, the OIG will strive to improve the scope, timeliness and thoroughness of it's oversight of NASA programs and operations, identify preventive measures, and enhance its capability to assist NASA management to efficiently and effectively achieve program goals.

FISCAL YEAR 1994 CONGRESSIONAL BUDGET

DISTRIBUTION OF PERMANENT WORKYEARS BY PROGRAM

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Full-time permanents.....	196	206	204	200
Other controlled FTE's.....	10	10	10	10
Total (full-time equivalents)....	206	216	214	210

SUMMARY OF RESOURCES REQUIREMENTS

FUNDING PLAN BY FUNCTION

		1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
			(Thousands of Dollars)		
I.	Personnel & related costs.....	12,375	14,366	13,927	14,067
II.	Travel.....	698	756	725	780
III.	Operation of installation.....	804	778	410	653
	A. Facilities services.....	(--)	(--)	(--)	(--)
	B. Technical services.....	(638)	(513)	(305)	(500)
	C. Management & operations.....	(166)	(265)	(105)	(153)
	Total. fund requirements...	13,877	15,900	15,062	15,500

RESOURCES REQUIREMENTS BY FUNCTION

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
I. PERSONNEL & RELATED COSTS.....	12.375	14.366	13.927	14.067
Summary of Fund Requirements				
A. Compensation & benefits				
1. Compensation				
a. Full-time permanent.....	8.748	10.600	10.450	10.502
b. Other than full-time permanent	324	220	330	350
c. Overtime & other compensation	281	215	225	245
Subtotal.....	9.353	11.035	11.005	11.097
2. Benefits.....	1,702	1,788	2,092	2,230
Subtotal. compensation & Benefits.....	11,055	12,823	13,097	13,327
B. Supporting costs				
1. Transfer of personnel.....	1.200	1.348	690	600
2. Personnel training.....	120	175	130	130
3. OPM services.....	--	20	10	10
Subtotal. support costs.	1,320	1,543	830	740
Total, personnel & related costs.....	12,375	14,366	13,927	14,067

EXPLANATION OF FUND REQUIREMENTS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
A. Compensation and benefits.....	11,055	12,823	13,097	13,327
1. Compensation.....	9,353	11,035	11,005	11,097
a. Full-time permanent.....	8,748	10,600	10,450	10,502

Basis of Cost for Permanent Positions

In 1994 the cost of permanent workyears will be $10,502,000. The increase from 1993 results from the following:

Cost of full-time permanent workyears in 1993			10,450	
Cost changes in 1994			52	
Within-grade and career advances	+52			
Cost of full-time permanent workyears in 1994				10,502
b. Other than full-time permanent				
1. Cost.....	324	220	330	350
2. Workyears.....	10	10	10	10
c. Overtime & other compensation	281	215	225	245

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
2. Benefits.....	1,702	1,788	2,092	2,230
Contributions by category:				
Retirement fund & thrift plan.....	1,003	1,035	1,163	1,229
Employee life insurance.....	18	18	24	27
Employee health insurance.....	374	450	470	505
Workmen's compensation.....	--	22	20	24
FICA.....	172	137	250	265
Medicare.....	135	126	165	180
Total	1,702	1,788	2,092	2,230
B. Supporting costs.....	1,320	1,543	830	740
1. Transfer of personnel.....	1.200	1.348	690	600

The costs associated with transfer of personnel include movement of household goods, subsistence and temporary expenses, and real estate and miscellaneous moving expenses related to change of duty station.

2. Personnel training.....	120	175	130	130

The maintenance and expansion of skills through various training and educational activities is essential in carrying out the Inspector General's mission. Part of the training consists of courses offered by other Government agencies, usually for a fee. The remainder of the training is provided through non-government sources. The costs are for tuition, fees, and related costs for training at colleges, universities and technical institutions, and also to cover the costs associated with seminars and workshops. The 1994 training funds are needed not only for routine training, but also to fund training requirements mandated by the GAO audit standards and training for Financial Management Audits.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
3. OPM services (Headquarters only)	--	20	10	10

The costs associated with the Office of Personnel Management's (OPM) investigation of new hires for the Office of Inspector General are included here. In FY 1992, NASA OIG conducted investigations of new hires due to a backlog at OPM, however OPM will conduct a large percentage of these investigations in FY 1993 and FY 1994.

II. TRAVEL.....	698	756	725	780

Summary of Fund Requirements

Travel funding is required to carry out audit, investigation and management duties. The increase from the current estimate in 1993 to the 1994 budget estimate is due to increased per-diem, increased airline costs, and increased workload.

III. OPERATION OF INSTALLATION.....	804	778	410	653
A. Technical services.....	638	513	305	500
B. Management and operations.....	166	265	105	153

Explanation of Fund Requirements

Operation of Installation provides a broad range of services and equipment in support of the Inspector General's activities.

A. Technical services.....	638	513	305	500

This estimate provides for all equipment, including the lease, purchase, maintenance, programming and operations services of automated data processing (ADP) equipment. NASA provides common services items such as office space, communications, supplies, and printing and reproduction at no charge to the Office of Inspector General. The funding for Technical Services will cover the cost of providing an EDP (electronic data processing) upgrade, equipment to employees, and replacing equipment that has become outdated or unserviceable. Also, as funding permits, minicomputers are being placed at OIG locations which presently are not part of the existing EDP system.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
B. Management and operations.....	166	265	105	153
Summary of Fund Requirements				
1. Administrative communications	--	--	--	--
2. Printing and reproductions.	--	--	--	--
3. Installation common services	166	265	105	153
Explanation of Fund Requirements				
3. Installation common services	166	265	105	153

Included in this category are miscellaneous expenses within the Office of Inspector General, i.e., GSA cars, the Inspector General's confidential fund, miscellaneous contracts, supplies not provided by NASA, etc. The increase in Installation Common Services will primarily allow for audit and investigative contractor support and other specialized activities which the OIG cannot perform internally.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

OFFICE OF INSPECTOR GENERAL

WORKLOAD

	1992 Actual	1993 Estimate	1994 Estimate
Office staff ceiling.....	206	214	210
Full-time permanents.....	196	204	200
Investigations			
Cases pending beginning of year.....	381	330	378
Opened during year.....	349	408	424
Closed during year.....	400	360	374
Cases pending end of year.....	330	378	428
Audits			
Audits pending beginning of year.....	74	73	76
Opened during year.....	73	80	80
Closed during year.....	74	77	79
Audits pending end of year.....	73	76	77

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PROPOSED APPROPRIATION LANGUAGE

Office of Inspector General

For necessary expenses of the Office of the Inspector General in carrying out the provisions of the Inspector General Act of 1978, as amended, [$15,062,000] *$15,500,000. (Departments of Veterans Affairs and Housing and Urban Development, and Independent Agencies Appropriations Act, 1993.)*

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RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1994 ESTIMATES

JET PROPULSION LABORATORY

DESCRIPTION

The Jet Propulsion Laboratory (JPL) is located in Pasadena, California, approximately 30 Kilometers north of downtown Los Angeles with subsidiary facilities located at Goldstone, California (tracking and data acquisition), Edwards Air Force Base, California (hazardous testing), Table Mountain, California (atmospheric remote sensing, solar studies and astronomy), Kennedy Space Center (KSC), Florida (support of JPL launches at KSC), Vienna, Virginia (support to the Technology and Applications Programs Office), and Washington, DC (support to the Visiting Senior Scientist and JPL Detailee Programs).

At Pasadena, the Laboratory occupies 177 acres of land of which 156 acres, at the Oak Grove site are owned by NASA and 21 acres are leased. Approximately 85 percent of the employees are located at the Oak Grove site. At Goldstone, facilities are located on land occupied under permit from the Army. At Edwards Air Force Base, facilities are located on land occupied under permit from the Air Force. The facilities at Table Mountain are located on land occupied under permit from the Forest Service of the Department of Agriculture. The Eastern Launch Site Office is located at Kennedy Space Center; the other east coast offices are leased. The capital investment of the Jet Propulsion Laboratory, including the Deep Space Network (DSN), fixed assets in progress, and contractor held facilities, as of September 30, 1992, was $977,923,023.

The JPL is a Government-owned installation that is staffed and managed by the California Institute of Technology. Contract NAS7-918 between NASA and Caltech governs research, development, and related activities at the laboratory with facilities being provided under a separate facilities contract NAS7-920(F). The cost of operating JPL for NASA activities is borne by the Research and Development (R&D) and the Space Flight, Control, and Data Communications (SFCDC) appropriations. Accordingly, the Research and Program Management (R&PM) costs presented in this special analysis for JPL are for purposes of comparison only and are not a part of the NASA R&PM budget.

ROLES AND MISSIONS

The JPL is responsible for the conduct of NASA missions concerned with scientific exploration of the solar system and deep space; for spacecraft tracking and data acquisition; for research and analysis; and for the development of advanced spacecraft technologies including propulsion, power, structures, guidance and control systems, thermal control, electronics, and others. The Laboratory is also assigned responsibility for selected Earth-orbital projects and for the development and application of earth remote sensing technology and instruments. Implicit in these assignments is a broad range of engineering, scientific, and management functions devoted to:

1. The conduct of complete spaceflight projects, including overall project management and all phases of project activity beginning with mission design and following with spacecraft design, development, testing, flight operations, and data analysis.

2. The development and operation of the Deep Space Network (DSN) which provides tracking and data acquisition services for all NASA projects involving missions beyond near-earth orbits.

3. Continuing programs of scientific investigation, research and analysis, instrument and technology development.

In more specific terms, the principal Laboratory activities in support of NASA can be categorized as follows:

Solar System Exploration - Since the beginning of the Nation's space activities, JPL has devoted a major part of its efforts to exploration of the planets, their satellites, and the interplanetary medium. The Laboratory has had project responsibility for all of the Mariner missions, including design, fabrication, assembly and testing of the spacecraft. During almost three decades, beginning with the Mariner 2 flight to Venus in 1962, these missions produced enormous scientific returns.

In the continuing series of planetary missions, JPL has project responsibility for the Voyager mission. The two Voyager spacecraft were launched in 1977 and made close flybys of Jupiter and its major satellites in 1979. In 1980 and 1981, the Voyager spacecraft encountered Saturn. Each of these four Voyager planetary encounters resulted in major scientific discoveries and obtained unique data. Both spacecraft remained in good operating condition following the Saturn encounters, and in consequence the Voyager mission was considerably extended beyond its original objectives. Voyager 2 was targeted to a flyby of Uranus, which occurred in January 1986, with highly satisfactory scientific results, and has completed its "grand tour" of the solar system with a flyby of Neptune in August 1989. Voyagers 1 and 2 continue to collect and transmit data on the space environment beyond the solar system.

The Laboratory also has project responsibility for the Galileo mission, which will orbit Jupiter and release an instrumented probe to make in-situ measurements of the physical and chemical properties of the Jovian atmosphere. During its 22 month prime mission, the orbiter will observe Jupiter and its system of satellites at close range. JPL is the management center for the Galileo project and developed the orbiter in-house. The Ames Research Center was responsible for the probe development. Galileo was launched successfully in October 1989, flew by Venus in February 1990, by Earth for the first time in December 1990, and encountered the asteroid Gaspra in October 1991. The spacecraft flew by the Earth again in December 1992 on its final journey to the outer solar system, and will arrive at Jupiter in December 1995.

The Magellan mission has obtained high resolution global radar imagery and altimetric coverage of 99% of Venus. Gravity data continues to be acquired from the spacecraft until termination in May 1993. The objectives are to address fundamental questions regarding the origin and evolution of the planet. Magellan was launched successfully in May 1989, and inserted into orbit in August 1990. The primary data gathering period lasted over one Venusian year equal to 243 earth days. Magellan is now completing its extended mission phase. JPL manages the project, including responsibility for mission design and operations. Industry developed the spacecraft and synthetic aperture radar under contracts to JPL.

The Ulysses Project is a cooperative effort between NASA and the European Space Agency (ESA) to study the Sun at high solar latitudes. The JPL managed the development of United States instruments on the ESA spacecraft, plus the corresponding data analysis. In addition, JPL is providing mission support to ESA. ESA developed the spacecraft and a set of its own instruments. Ulysses was launched by the Shuttle in October 1990, arrived at Jupiter in February 1992 for a gravity assist, where it acquired new data on the space environment around Jupiter. The spacecraft is now turned back towards the inner solar system for a south polar pass around the Sun in September 1994.

The Mars Observer mission will undertake planet-wide studies of the composition and physical state of Martian materials, examine the major surface forming processes and their time scales, and explore the structure and circulation aspects of the atmosphere. The JPL is the management center with responsibility for the scientific payload, and contracted with industry for development of the spacecraft bus. Mars Observer was launched by a Titan III expendable launch vehicle in September 1992, and will arrive at Mars in August 1993.

JPL also has project responsibility for the Cassini mission which will undertake investigations of the planet Saturn. The scientific goals are to determine cloud properties and atmospheric composition, determine atmospheric wind velocities and temperatures, and study the internal structure and rotation of the planet. The Cassini spacecraft payload includes radar, visible infrared mapping spectrometer, imaging, and an ESA (Huygens) probe that will investigate one of Saturn's moons, Titan. The launch date is planned for October 1997.

Life and Microgravity Sciences and Applications - In the area of Life and Microgravity Sciences, JPL has some responsibility for fluids and low temperature research experiments. Microgravity experiments developed for Shuttle flights include the Drop Physics Module and the Lambda Point Experiment, both of which flew in 1992.

Astrophysics - Consistent with its role as a center for Earth-orbital spacecraft development, JPL managed the Infrared Astronomical Satellite (IRAS) project which was launched in January 1983. IRAS has been a highly successful scientific undertaking, producing a database comprised of photometric observations of asteroids, stars, and galaxies in four wavelength bands from near to far infrared. This unique database is of such size that analysis will continue for many years.

Technology development for a possible infrared-astronomy mission is being carried out. The associated detector arrays would permit a thousand-fold gain in sensitivity for astrophysical observations.

The Wide Field/Planetary Camera I (WF/PC I), developed and fabricated at JPL, was orbited successfully as an instrument on the Hubble Space Telescope in April 1990. JPL's WF/PC II, with optics to correct the spherical aberration of the Hubble, will be delivered in May 1993 and launched in December 1993.

Mission to Planet Earth - JPL is a principal center for work in oceanographic applications of space technology. Development was initiated in FY 1987 on the Ocean Topography Experiment (Topex/Poseidon), a cooperative effort with the French government to develop an ocean-observing satellite which will map the circulation of the Earth's oceans. The satellite was launched by the French Ariane in August 1992 and mission operations are currently underway. JPL has project management responsibility for the TOPEX/Poseidon, as well as responsibility for mission operations and science data processing.

The Laboratory also conducts significant activities in upper atmospheric and Earth resources research and in development and implementation of remote sensing techniques for Earth observations. Major flight instruments and experiments include the Shuttle borne Atmospheric Trace Molecule Spectrometers, the Upper Atmosphere Research Satellite (UARS) Microwave Limb Sounder and the Active Cavity Radiometer Irradiance Monitor II, (both launched on the UARS in September 1991) the Shuttle Radar Lab-1 (expected to fly in 1994), and the NASA Scatterometer on the Japanese ADEOS spacecraft to be launched in 1996. In addition, a variety of instruments are being studied and developed for the Earth Observation System (EOS). Finally, geodynamics and plate tectonics are two other important areas of earth science research.

Spacecraft Flight Operations - The Jet Propulsion Laboratory is responsible for the design, development, maintenance, and operation of NASA's worldwide Deep Space Network (DSN) and a multi-mission Space Flight Operations Center (SFOC). The DSN tracking stations are located in California, Spain, and Australia, and support projects involving flights beyond near-Earth orbit, including some international missions. The Space Flight Operations Center is located at JPL, and is the facility for actual day-to-day operations of

deep-space missions. JPL also implemented the Network Consolidation Program which co-locates major facilities of the Space Tracking and Data Network (STDN) near-Earth tracking stations with the three DSN stations. These consolidated facilities are managed by JPL and provide an efficient, technically advanced, and cost effective means of operation.

Research and Analysis - The Jet Propulsion Laboratory maintains an effective program of advanced technical development to provide technologies for present and prospective project assignments and to further the general capabilities of NASA. Areas of involvement include spacecraft advanced technology and development, controls and robotics, space power and propulsion, structures, microelectronics and sensors, information systems, advanced computer concepts, and satellite communications. Ground based research programs are carried out in the planetary sciences, physics and astronomy, and Earth and ocean physics. These activities involve broad collaboration with the scientific and academic communities and with staff members from other NASA field installations.

JET PROPULSION LABORATORY
FY 1994 SIMULATED RESEARCH AND PROGRAM MANAGEMENT (R&PM)
DISTRIBUTION OF PERMANENT WORKYEARS BY PROGRAM

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
Space Station and New Technology Investments	25	16	25	25*
Space Flight Programs	6	15	6	6
Space Transportation Capability Development	3	6	3	3
Space Shuttle	3	9	3	3
Space Science	1,500	1,509	1,475	1,487
Physics and Astronomy	206	188	203	202
Planetary Exploration	1,294	1,321	1,272	1,285
Life Science	19	15	19	
Life and Microgravity Sciences				67
Space Applications	695	680	683	
Mission to Planet Earth				623
Space Research and Technology	194	171	191	191
Commercial Programs	10	4	10	10
Aeronautica Research and Technology	8	3	8	8
Safety, Reliability, Maintainability & Quality Assurance	26	28	26	26
Tracking and Data	502	471	494	494
DIRECT SUPPORT	553	672	545	545
CENTER MANAGEMENT AND OPERATIONS	1,624	1,890	1,597	1,599
Total, Permanent Workyears	5,162	5,474	5,079	5,081

* Currently under review

JET PROPULSION LABORATORY 1994
FY 1994 SIMULATED RESEARCH AND PROGRAM MANAGEMENT (R&PM)
FUNDING PLAN BY FUNCTION

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
I. Personnel and Related Costs.....	387,701	407,662	403,968	422,065
II. Travel.....	15,398	15,408	16,104	16,861
Total, Fund Requirements.....	403,099	423,070	420,072	438,926

EXPLANATION OF FUND REQUIREMENTS

I. Personnnel and Related Costs.....	387,701	407,662	403,968	422,065

The decrease from the 1993 Budget Estimate to the 1993 Current Estimate is due to the change in estimated workforce levels, revised salary estimates based on 1992 experience, and related benefit costs. The increase from the 1993 Current Estimate to the 1994 Estimate is due to normal salary increases, associated increases in personnel benefits, and the change in the estimated workforce level.

II. Travel.....	15,398	15,408	16,104	16,861

The increase from the 1993 Budget Estimate to the 1993 Current Estimate is due to a reassessment of travel requirements based on current programmatic activities. The increase from the 1993 Current Estimate to the 1994 Budget Estimate reflects increased Travel Costs levels.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1994 ESTIMATES

BUDGET SUMMARY

OFFICE OF AERONAUTICS — AIR TRANSPORTATION

SUMMARY OF RESOURCES REQUIREMENTS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Research and development.....	557,487	687,000	716,762	917,200
Research operations support.....	104,007	110,885	71,077	69,768
Construction of facilities.....	42,300	50,100	75,100	212,000
Research and program management.....	282,074	290,220	299,409	315,745
Total.....	985,868	1,138,205	1,162,348	1,514,713
Number of direct workyears associated with air transportation.....	3,357	3,326	3,416	3,462

The goal of the NASA program is to conduct aeronautical research and develop technology to strengthen U.S. leadership in civil and military aviation. The program is based on a strong commitment to develop a broad technology base in support of the aviation industry, enhance the safety and capacity of the national airspace system, and assure U.S. superiority for national security. The FY 1994 estimate reflects the need to address critical barriers and strengthen technology development in selected high payoff areas that are vital to our long-term leadership in aviation. NASA's Aeronautics program is focused on six thrusts: (1) develop selected, high-leverage technologies and explore new means to enhance capabilities of U.S. subsonic aircraft and to enhance the safety and productivity of the national aviation system; (2) resolve the critical environmental issues and establish the technology foundation for economical, high-speed air transportation; (3) ready technology options for revolutionary new capabilities in future high-performance fixed- and rotary-wing aircraft; (4) develop critical technologies and new methodologies for hypersonic cruise and air-breathing space launch vehicles; (5) pioneer the development of innovative concepts, and provide the physical understanding and the theoretical, experimental, and computational tools required for the efficient design and operation of advanced aerospace systems; and (6) develop, maintain and operate

critical national facilitiea for aeronautical research and for support of induatry. Department of Defenae (DOD) and other NASA programs. In accomplishing these thrusts. the program will maintain NASA laboratory atrength, including enhanced experimental and computational capabilities and staff excellence; enaure timely domeatic technology transfer; ensure strong university involvement; and ensure atrong support for and cooperation with the DOD. Federal Aviation Administration. and industry partners.

The Transatmospheric Research and Technology program is the NASA portion of the National Aero-Space Plane (NASP) program. which is jointly managed and funded by NASA and the DOD. The objective of the NASP program is to develop and then demonstrate the technology required to permit the Nation to develop and to fly a reusable. single-stage-to-orbit vehicles with airbreathing primary propulsion as well as horizontal takeoff and landing.

The Research and Program Management funding in FY 1994 provides for the salaries and travel of direct civil service workyears.

The Construction of Facilities funding in FY 1994 provides for continuation of the multiyear effort to restore and modernize NASA's aeronautical research and development facilities. In addition. a significant new initiative is included to expand the National Aeronautics Facilities Upgrade program begun in FY 1993.

The research operations support (ROS) funding is only that portion of the total ROS funding shown in the Aeronautical Research and Technology program which is associated with aeronautics.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1994

SUMMARY OF CONSULTING SERVICES ESTIMATES

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Research and Program Management				
Consultants employed by NASA.....	522	650	550	550
Contractual services.....	--	*14,685	--	--
Subtotal.....	522	15,335	550	550
Research and Development				
Contractual services.....	48,147	59,522	49,640	51,178
Space Flight, Control and Data Communications				
Contractual services.....	2,894	2,093	2,984	3,076
Total, NASA.....	51,563	76,950	53,174	54,804

* The FY 1993 Research and Program Management Budget Estimate for Contractual Services was developed without considering the fact that the Operation of Installation account of that appropriation had recently been transferred from Research and Program Management into the Research and Development and Space Flight, Control and Data Communications appropriations. If this transfer had been properly reflected the FY 1993 Budget Estimate would have been zero.

NASA uses paid consultants and consulting services contracts to provide advice and expert input in addition to or beyond that available from its in-house civil service workforce. Management controls are established which assure that before entering into either a consultant services arrangement with an individual or consulting services contract, there is ample justification presented and the action is approved at top management levels. The use to which these activities will be put is as follows:

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Research and Program Management				
Consultants employed by NASA.....	522	650	550	550

NASA hires experts and consultants to provide expert advice and input on the selection of experiments for future space missions. The use of contract employees, in addition to NASA civil service personnel, provides the Agency with an independent view that assures the selection of experiments likely to have the greatest scientific merit. Other individuals are employed to provide independent looks at technical and functional problems in order to give top management the widest range of views before making major decisions.

Contractual services.....	--	14,685	--	--

NASA contracts with consulting services firms for studies of management policies and programs in such areas as ADP, life sciences, microgravity, space physics, utility consumption, safety, reliability and quality assurance, and strategic planning.

Research and Development				
Contractual services.....	48,147	59,522	49,640	51,178

In consonance with its legislative charter, NASA seeks advice from many sources in the private sector on what would be the most productive future programs. The purpose for seeking such advice is to assure the widest review of programmatic thrust is available. Funds are required to provide external expertise and input into organizational decisions, and evaluation of program effectiveness. In 1994, the funds will be used to support analyses conducted by the National Academy of Sciences, and others in support of most research and development programs.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Space Flight, Control and Data Communications				
Contractual services.....	2,894	2,093	2,984	3,076

NASA hires experts and consultants to provide advice on space flight operations, mission planning, operations research, feasibility studies, computer program support, and safety, reliability and quality assurance.

DETAIL OF PERMAMENT POSITIONS

NASA TOTAL	FY 1992	FY 1993	FY 1994
Executive level II	1	1	1
Executive level III	0	0	0
Executive level V	0	0	0
	1	1	1
ES-6	50	50	50
ES-5	129	129	129
ES-4	299	291	283
ES-3	27	27	27
ES-2	24	32	40
ES-1	34	34	34
	563	563	583
CA	2	2	2
SL/ST	44	44	44
GS/GM-15	2,540	2,655	2,730
GS/GM-14	3,914	3,990	4,028
GS/GM-13	5,785	5,805	5,828
GS-12	3,636	3,672	3,695
GS-11	2,316	2,204	2,143
GS-10	332	362	377
GS-09	985	891	854
GS-08	355	385	400
GS-07	927	813	752
GS-06	745	819	856
GS-05	986	867	820
GS-04	188	168	188
GS-03	13	13	13
GS-02	8	8	8
	22,718	22,718	22,718
SPECIAL UNGRADED POSITIONS ESTABLISHED BY NASA ADMINISTRATOR	15	15	15
UNGRADED POSITIONS	711	711	711
TOTAL PERMAMENT POSITIONS	24,008	24,008	24,008
UNFILLED POSITIONS, EOY	0	0	0
TOTAL PERM EMPLOYMENT, EOY	24,008	24,008	24,008

PERSONNEL SUMMARY

	FY 1992	FY 1993	FY 1994
AVERAGE GS/GM GRADE	11.8	11.9	11.9
AVERAGE ES SALARY	$104,185	$109,131	$110,768
AVERAGE GS/GM SALARY	$49,768	$52,383	$53,169
AVERAGE SALARY OF SPECIAL UNGRADED POSITIONS ESTAB-LISHED BY NASA ADMINISTRATOR	$97,660	$102,793	$104,335
AVERAGE SALARY OF UNGRADED POSITIONS	$44,998	$47,363	$48,073

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

ESTIMATED FY 1994 EQUIPMENT OBLIGATIONS TO BE PLACED
AT NASA INSTALLATIONS

	(MILLIONS OF DOLLARS)
RESEARCH AND DEVELOPMENT	334.3
Space Station	138.4*
Space Transportation Capability Development	22.6
Physics and Astronomy	3.0
Planetary Exploration	17.6
Mission to Planet Earth	48.7
Space Research and Technology	9.9
Aeronautical Research and Technology	94.1
SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS	166.9
Shuttle Production and Operational Capability	83.9
Shuttle Operations	42.9
Launch Services	0.8
Space and Ground Networks, Communications and Data Systems	39.3
TOTAL	501.2

*Currently under review

SUMMARY OF MAJOR ADP EQUIPMENT AQUISITION OBLIGATIONS

PROGRAM BUDGET LINE ITEM	RECEIVING INSTALLATION BUILDING LOCATION, AND AOP/EAO CONTROL NUMBER	EQUIPMENT DESCRIPTION	PROGRAMMATIC PURPOSE	FY(94) OBLIGATIONS ($ IN THOUSANDS)
SPACE STATION	HEADQUARTERS LOCATION 1001-T1, 940086	TECHNICAL & MGMT INFORMATION SYS (TMIS)-SPACE STATION TMIS H/W (D)	PROGRAM ENGINEERING AND INTEGRATION (PE&I)	1520.0
SPACE STATION	HEADQUARTERS LOCATION 1001-T2, 940088	ENGINEERING INTEGRATION OFFICE IRM-LEVEL II EIO (JSC) H/W (D)	PROGRAM ENGINEERING AND INTEGRATION (PE&I)	262.0
SPACE STATION	AMES RESEARCH CENTER LOCATION 21FI-00, 940036	INFORMATION SCIENCES DIVISION-SPACE STATION FLIGHT SYSTEM	PROGRAM ENGINEERING AND INTEGRATION (PE&I)	336.1
SPACE STATION	LEWIS RESEARCH CENTER LOCATION 2202-B5, 920026	SPACE STATIN SUPPORT-SPACE STATION SUPPORT SYSTEM HW	OPERATIONS/ UTILIZATION CAPABILITY DEVELOPMENT (OUCD)	1314.0
SPACE STATION	MARSHALL SPACE FLIGHT CENTER LOCATION 6203-CP, 940020	Central Processing System-CENTRAL PROCESSING SYSTEM	OPERATIONS/ UTILIZATION CAPABILITY DEVELOPMENT (OUCD)	933.0
SPACE STATION	MARSHALL SPACE FLIGHT CENTER LOCATION 6203-ED, 940024	Enhanced Data System-ENHANCED DATA SYSTEM	OPERATIONS/ UTILIZATION CAPABILITY DEVELOPMENT (OUCD)	12813.0
SPACE STATION	MARSHALL SPACE FLIGHT CENTER LOCATION 6203-MS, 940032	Mission Support Services System-MISSION SUPPORT SERVICES SYSTEM	OPERATIONS/ UTILIZATION CAPABILITY DEVELOPMENT (OUCD)	2194.0
SPACE STATION	MARSHALL SPACE FLIGHT CENTER LOCATION 6203-PD, 940036	Payload Data Services System-PAYLOAD DATA SERVICES SYSTEM	OPERATIONS/ UTILIZATION CAPABILITY DEVELOPMENT (OUCD)	1000.0

SUMMARY OF MAJOR ADP EQUIPMENT AQUISITION OBLIGATIONS

PROGRAM BUDGET LINE ITEM	RECEIVING INSTALLATION BUILDING LOCATION, AND ADP/EAD CONTROL NUMBER	EQUIPMENT DESCRIPTION	PROGRAMMATIC PURPOSE	FY(94) OBLIGATIONS ($ IN THOUSANDS)
SPACE STATION	HEADQUARTERS LOCATION 1001-T1, 940086	TECHNICAL & MGMT INFORMATION SYS (TMIS)-SPACE STATION TMIS H/W (O)	PROGRAM ENGINEERING AND INTEGRATION (PE&I)	1520.0
SPACE STATION	HEADQUARTERS LOCATION 1001-T2, 940088	ENGINEERING INTEGRATION OFFICE IRM-LEVEL II EIO (JSC) H/W (O)	PROGRAM ENGINEERING AND INTEGRATION (PE&I)	262.0
SPACE STATION	AMES RESEARCH CENTER LOCATION 21FI-00, 940036	INFORMATION SCIENCES DIVISION-SPACE STATION FLIGHT SYSTEM	PROGRAM ENGINEERING AND INTEGRATION (PE&I)	336.1
SPACE STATION	LEWIS RESEARCH CENTER LOCATION 2202-85, 920026	SPACE STATIN SUPPORT-SPACE STATION SUPPORT SYSTEM HW	OPERATIONS/ UTILIZATION CAPABILITY DEVELOPMENT (OUCD)	1314.0
SPACE STATION	MARSHALL SPACE FLIGHT CENTER LOCATION 6203-CP, 940020	Central Processing System-CENTRAL PROCESSING SYSTEM	OPERATIONS/ UTILIZATION CAPABILITY DEVELOPMENT (OUCD)	933.0
SPACE STATION	MARSHALL SPACE FLIGHT CENTER LOCATION 6203-ED, 940024	Enhanced Data System-ENHANCED DATA SYSTEM	OPERATIONS/ UTILIZATION CAPABILITY DEVELOPMENT (OUCD)	12813.0
SPACE STATION	MARSHALL SPACE FLIGHT CENTER LOCATION 6203-MS, 940032	Mission Support Services System-MISSION SUPPORT SERVICES SYSTEM	OPERATIONS/ UTILIZATION CAPABILITY DEVELOPMENT (OUCD)	2194.0
SPACE STATION	MARSHALL SPACE FLIGHT CENTER LOCATION 6203-PD, 940036	Payload Data Services System-PAYLOAD DATA SERVICES SYSTEM	OPERATIONS/ UTILIZATION CAPABILITY DEVELOPMENT (OUCD)	1000.0

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SUMMARY OF MAJOR ADP EQUIPMENT AQUISITION OBLIGATIONS

PROGRAM BUDGET LINE ITEM	RECEIVING INSTALLATION BUILDING LOCATION, AND ADP/EAD CONTROL NUMBER	EQUIPMENT DESCRIPTION	PROGRAMMATIC PURPOSE	FY(94) OBLIGATIONS ($ IN THOUSANDS)
SPACE STATION	MARSHALL SPACE FLIGHT CENTER LOCATION 6203-P1, 940042	Payload Training Complex-PAYLOAD TRAINING COMPLEX	OPERATIONS/ UTILIZATION CAPABILITY DEVELOPMENT (OUCD)	906 0
SPACE STATION	MARSHALL SPACE FLIGHT CENTER LOCATION 6218-02, 940072	Telecommunications Mission Services-TELECOM MSN SVCS EQUIPMENT	PRESSURIZED MODULES	2110 0
SPACE STATION	JOHNSON SPACE CENTER LOCATION 72DA-05, 940042	Space Station Training Facility-MISSION OPS DIR OPS AUTO DATA PROCESSING	OPERATIONS/ UTILIZATION CAPABILITY DEVELOPMENT (OUCD)	4810 0
SPACE STATION	JOHNSON SPACE CENTER LOCATION 720A-05, 940044	Space Station Training Facility-SPACE STATION TRNG FAC COMPUTATIONAL HOST	OPERATIONS/ UTILIZATION CAPABILITY DEVELOPMENT (OUCD)	16957 0
SPACE STATION	JOHNSON SPACE CENTER LOCATION 720A-05, 940046	Space Station Training Facility-SPACE STATION TRNG FAC DATA DISTRIBUTION SYS	OPERATIONS/ UTILIZATION CAPABILITY DEVELOPMENT (OUCD)	841 0
SPACE STATION	JOHNSON SPACE CENTER LOCATION 720A-05, 940048	Space Station Training Facility-SPACE STATION TRNG FAC DEV & OPERATIONAL SUPP SYS	OPERATIONS/ UTILIZATION CAPABILITY DEVELOPMENT (OUCD)	1366 0
SPACE STATION	JOHNSON SPACE CENTER LOCATION 720A-05, 940050	Space Station Training Facility-SPACE STATION TRNG FAC EXTERNAL SIMULATION SYS	OPERATIONS/ UTILIZATION CAPABILITY DEVELOPMENT (OUCD)	917 0

SUMMARY OF MAJOR ADP EQUIPMENT AQUISITION OBLIGATIONS

PROGRAM BUDGET LINE ITEM	RECEIVING INSTALLATION BUILDING LOCATION, AND AOP/EAD CONTROL NUMBER	EQUIPMENT DESCRIPTION	PROGRAMMATIC PURPOSE	FY(94) OBLIGATIONS ($ IN THOUSANDS)
SPACE STATION	JOHNSON SPACE CENTER LOCATION 720A-05, 940052	Space Station Training Facility-SPACE STATION TRNG FAC IMPROVEMENT	SPACE STATION OPERATIONS	327.0
SPACE STATION	JOHNSON SPACE CENTER LOCATION 720A-05, 940054	Space Station Training Facility-SPACE STATION TRNG FAC INSTRUCT & OPERATOR STATION	OPERATIONS/ UTILIZATION CAPABILITY DEVELOPMENT (OUCD)	797.0
SPACE STATION	JOHNSON SPACE CENTER LOCATION 720A-05, 940056	Space Station Training Facility-SPACE STATION TRNG FAC PART TASK TRAINER	OPERATIONS/ UTILIZATION CAPABILITY DEVELOPMENT (OUCD)	1690 0
SPACE STATION	JOHNSON SPACE CENTER LOCATION 720A-05, 940058	Space Station Training Facility-SPACE STATION TRNG FAC PROJECT SUPPORT	OPERATIONS/ UTILIZATION CAPABILITY DEVELOPMENT (OUCD)	450.0
SPACE STATION	JOHNSON SPACE CENTER LOCATION 720A-05, 940060	Space Station Training Facility-SPACE STATION TRNG FAC VISUAL SYS	OPERATIONS/ UTILIZATION CAPABILITY DEVELOPMENT (OUCD)	7510.0
SPACE STATION	JOHNSON SPACE CENTER LOCATION 720A-06, 940062	Space Station Control Center-MISSION OPS DIR OPS AUTO DATA PROCESSING	OPERATIONS/ UTILIZATION CAPABILITY DEVELOPMENT (OUCD)	1057.0
SPACE STATION	JOHNSON SPACE CENTER LOCATION 720A-06, 940066	Space Station Control Center-SPACE STATION CONTROL CNTR COMM & DATA SYS	OPERATIONS/ UTILIZATION CAPABILITY DEVELOPMENT (OUCD)	5349 0

SUMMARY OF MAJOR ADP EQUIPMENT AQUISITION OBLIGATIONS

PROGRAM BUDGET LINE ITEM	RECEIVING INSTALLATION BUILDING LOCATION, AND ADP/EAD CONTROL NUMBER	EQUIPMENT DESCRIPTION	PROGRAMMATIC PURPOSE	FY(94) OBLIGATIONS ($ IN THOUSANDS)
SPACE STATION	JOHNSON SPACE CENTER LOCATION 72DA-D6, 940068	Space Station Control Center-SPACE STATION CONTROL CNTR DATA STORAGE SYS	OPERATIONS/ UTILIZATION CAPABILITY DEVELOPMENT (OUCD)	1175 0
SPACE STATION	JOHNSON SPACE CENTER LOCATION 72DA-D6, 940074	Space Station Control Center-SPACE STATION CONTROL CNTR PROJECT SUPPORT	OPERATIONS/ UTILIZATION CAPABILITY DEVELOPMENT (OUCD)	1000 0
SPACE STATION	JOHNSON SPACE CENTER LOCATION 72DA-D6, 940076	Space Station Control Center-SPACE STATION CONTROL CNTR STANDARD ELEMENTS	OPERATIONS/ UTILIZATION CAPABILITY DEVELOPMENT (OUCD)	4304 0
SPACE STATION	JOHNSON SPACE CENTER LOCATION 72EA-ER, 940112	Automation and Robotics	ASSEMBLY HARDWARE/ SUBSYSTEMS	1642 0
SPACE STATION	JOHNSON SPACE CENTER LOCATION 72KA-K2, 940160	Data Support Systems-JSC DATA SUPPORT SYSTEM UPGRADE	ASSEMBLY HARDWARE/ SUBSYSTEMS	369 0
SPACE STATION	JOHNSON SPACE CENTER LOCATION 72KA-K3, 940164	SSE Development Facility-RATIONAL - HW/SW	PROGRAM ENGINEERING AND INTEGRATION (PE&I)	586 0
SPACE STATION	JOHNSON SPACE CENTER LOCATION 72KA-K3, 940166	SSE Development Facility-WORKSTATIONS & HOSTS - HW/SW	PROGRAM ENGINEERING AND INTEGRATION (PE&I)	2342 0
SPACE STATION	JOHNSON SPACE CENTER LOCATION 72KA-K5, 940168	CSF/CAF-AUTOMATIC DATA PROCESSING EQPMT TEST EXECUTION SYS	ASSEMBLY HARDWARE/ SUBSYSTEMS	1629 0

SUMMARY OF MAJOR ADP EQUIPMENT AQUISTION OBLIGATIONS

PROGRAM BUDGET LINE ITEM	RECEIVING INSTALLATION BUILDING LOCATION, AND ADP/EAD CONTROL NUMBER	EQUIPMENT DESCRIPTION	PROGRAMMATIC PURPOSE	FY(94) OBLIGATIONS ($ IN THOUSANDS)
SPACE STATION	JOHNSON SPACE CENTER LOCATION 72KA-K5, 940170	CSF/CAF-AUTOMATIC DATA PROCESSING EQUIPMENT SUPPORT SYSTEM	ASSEMBLY HARDWARE/ SUBSYSTEMS	629.0
SPACE STATION	JOHNSON SPACE CENTER LOCATION 72SA-S4, 940232	Man-Systems Laboratories-SP/ MAN-SYSTEMS DIV FIPR HARDWARE	ASSEMBLY HARDWARE/ SUBSYSTEMS	1043.0
SPACE STATION	KENNEDY SPACE CENTER LOCATION 7612-02, 940090	Payload Data Management System-PAYLOAD DATA MANAGEMENT SYSTEMS	OPERATIONS/ UTILIZATION CAPABILITY DEVELOPMENT (OUCD)	2873.0
SPACE STATION	KENNEDY SPACE CENTER LOCATION 7624-FB, 940136	Space Station Test, Ctrl and Mntr Sys-SPACE STATION TEST, CONTROL AND MONITOR SYS	OPERATIONS/ UTILIZATION CAPABILITY DEVELOPMENT (OUCD)	10671.0
SPACE STATION	KENNEDY SPACE CENTER LOCATION 7624-FD, 940138	Space Station Software Dev Facility-SPACE STATION S/W DEVELOPMENT FACILITY	OPERATIONS/ UTILIZATION CAPABILITY DEVELOPMENT (OUCD)	1777.0
SPACE STATION	KENNEDY SPACE CENTER LOCATION 7624-B2, 940140	Automated Test Equipment-AUTOMATED TEST EQUIPMENT	OPERATIONS/ UTILIZATION CAPABILITY DEVELOPMENT (OUCD)	2639.0

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SUMMARY OF MAJOR ADP EQUIPMENT AQUISTION OBLIGATIONS

PROGRAM BUDGET LINE ITEM	RECEIVING INSTALLATION BUILDING LOCATION, AND ADP/EAD CONTROL NUMBER	EQUIPMENT DESCRIPTION	PROGRAMMATIC PURPOSE	FY(94) OBLIGATIONS ($ IN THOUSANDS)
SPACE TRANSPORTATION CAPABILITY DEVELOPMENT	MARSHALL SPACE FLIGHT CENTER LOCATION 6201-AC, 940012	Repository Auto. Optical Imaging System-REPOSITORY AUTOMATED OPTICAL IMAGING SYSTEM	OPERATIONS SUPPORT	430.0
SPACE TRANSPORTATION CAPABILITY DEVELOPMENT	MARSHALL SPACE FLIGHT CENTER LOCATION 6203-DD, 940022	Data Acquisition and Distribution System-DATA ACQUISITION AND DISTRIBUTION SYSTEM	SPACELAB OPERATIONS	4386.0
SPACE TRANSPORTATION CAPABILITY DEVELOPMENT	MARSHALL SPACE FLIGHT CENTER LOCATION 6203-PP, 940040	Peripheral Processing System-PERIPHERAL PROCESSING SYSTEM	SPACELAB OPERATIONS	3816.0
SPACE TRANSPORTATION CAPABILITY DEVELOPMENT	MARSHALL SPACE FLIGHT CENTER LOCATION 6206-04, 940050	ADVANCED PROPULSION TECH. SIMULATION-ADVANCED PROPULSION TECHNOLOGY	ADVANCED TRANSPORTATION TECHNOLOGY	2400.0
SPACE TRANSPORTATION CAPABILITY DEVELOPMENT	MARSHALL SPACE FLIGHT CENTER LOCATION 6213-01, 940068	Propulsion Test Data Acquisition System-PROPULSION TEST DATA ACQUISITION SYSTEM	ADVANCED TRANSPORTATION TECHNOLOGY	628.0
SPACE TRANSPORTATION CAPABILITY DEVELOPMENT	MARSHALL SPACE FLIGHT CENTER LOCATION 6201-01, 940086	Engineering Analysis and Data System-ENGINEERING ANALYSIS & DATA SYSTEM	RESEARCH & TEST OPERATIONS	13980.0
SPACE TRANSPORTATION CAPABILITY DEVELOPMENT	STENNIS SPACE CENTER LOCATION 6400- , 940012	Center ADP Activity-PROGRAM SUPPORT ADP EQUIPMENT PURCHASES	OPERATIONS SUPPORT	334.4
SPACE TRANSPORTATION CAPABILITY DEVELOPMENT	STENNIS SPACE CENTER LOCATION 6400-02, 940022	CADD Systems for General Use-FACILITY OPS SUPPORT CONTRACTOR CADD/ENGINEERING	OPERATIONS SUPPORT	425.8

SUMMARY OF MAJOR ADP EQUIPMENT AQUISITION OBLIGATIONS

PROGRAM BUDGET LINE ITEM	RECEIVING INSTALLATION BUILDING LOCATION, AND ADP/EAD CONTROL NUMBER	EQUIPMENT DESCRIPTION	PROGRAMMATIC PURPOSE	FY(94) OBLIGATIONS ($ IN THOUSANDS)
SPACE TRANSPORTATION CAPABILITY DEVELOPMENT	STENNIS SPACE CENTER LOCATION 6400-02, 940024	CADD Systems for General Use-FACILITY OPS SUPPORT CONTRACTOR/CADD ENGINEERING	OPERATIONS SUPPORT	330.0
SPACE TRANSPORTATION CAPABILITY DEVELOPMENT	STENNIS SPACE CENTER LOCATION 6400-03, 940026	Propulsion Test Operations-PROPULSION TEST OPERATIONS HARDWARE	ADVANCED TRANSPORTATION TECHNOLOGY	569 3
SPACE TRANSPORTATION CAPABILITY DEVELOPMENT	JOHNSON SPACE CENTER LOCATION 72NA-N1, 940176	JSC SR&DA Office Automation-LOCAL AREA NTWK/OFF AUTO CAPITAL INVESTMENT	RESEARCH & TEST OPERATIONS	360.3
SPACE TRANSPORTATION CAPABILITY DEVELOPMENT	JOHNSON SPACE CENTER LOCATION 72PA-P2, 940420	Engineering Computation Facility-ENG COMP FAC H/W LEASE TO OWNERSHIP PLAN	RESEARCH & TEST OPERATIONS	6693 0
SPACE TRANSPORTATION CAPABILITY DEVELOPMENT	KENNEDY SPACE CENTER LOCATION 7630-61, 940154	Payload Network System-PAYLOAD NETWORK SYSTEM	MULTIMISSION & PAYLOAD SUPPORT EQUIP	396 8

SUMMARY OF MAJOR ADP EQUIPMENT AQUISTION OBLIGATIONS

PROGRAM BUDGET LINE ITEM	RECEIVING INSTALLATION BUILDING LOCATION, AND ADP/EAD CONTROL NUMBER	EQUIPMENT DESCRIPTION	PROGRAMMATIC PURPOSE	FY(94) OBLIGATIONS ($ IN THOUSANDS)
SPACE SHUTTLE PRODUCTION AND OPERATIONAL CAPABILITY	JOHNSON SPACE CENTER LOCATION 72DA-02, 940032	Mission Control Center-MISSION CONTROL CENTER EQUIPMENT REPLACEMENT	LAUNCH AND MISSION SUPPORT	4850.0
SPACE SHUTTLE PRODUCTION AND OPERATIONAL CAPABILITY	JOHNSON SPACE CENTER LOCATION 72DA-07, 940080	Shuttle Mission Simulator-MISSION OPS DIR OPS AUTO DATA PROCESSING	LAUNCH AND MISSION SUPPORT	1927.0
SPACE SHUTTLE PRODUCTION AND OPERATIONAL CAPABILITY	JOHNSON SPACE CENTER LOCATION 72DA-07, 940082	Shuttle Mission Simulator-SHUTTLE MISSION TRNG FAC EQUIPMENT REPLACEMENT	LAUNCH AND MISSION SUPPORT	7398.0
SPACE SHUTTLE PRODUCTION AND OPERATIONAL CAPABILITY	JOHNSON SPACE CENTER LOCATION 72DA-07, 940084	Shuttle Mission Simulator-SHUTTLE MISSION TRNG FAC IMPROVEMENT	LAUNCH AND MISSION SUPPORT	310.0
SPACE SHUTTLE PRODUCTION AND OPERATIONAL CAPABILITY	JOHNSON SPACE CENTER LOCATION 72EA-EF, 940096	Software Development Facility-ACQUISITION OF S/W DEV FAC CAPITAL EQUIPMENT	ORBITER	608.0
SPACE SHUTTLE PRODUCTION AND OPERATIONAL CAPABILITY	JOHNSON SPACE CENTER LOCATION 72GA-G1, 940130	Integrated Management Information Center-INTEGRATED MANAGEMENT INFORMATION COMPUTER	ORBITER	2500.0
SPACE SHUTTLE PRODUCTION AND OPERATIONAL CAPABILITY	JOHNSON SPACE CENTER LOCATION 72GA-G1, 940132	Integrated Management Information Center-OFFICE AUTOMATION SYSTEM	LAUNCH AND MISSION SUPPORT	1000.0

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SUMMARY OF MAJOR ADP EQUIPMENT AQUISITION OBLIGATIONS

PROGRAM BUDGET LINE ITEM	RECEIVING INSTALLATION BUILDING LOCATION, AND ADP/EAD CONTROL NUMBER	EQUIPMENT DESCRIPTION	PROGRAMMATIC PURPOSE	FY(84) OBLIGATIONS ($ IN THOUSANDS)
PHYSICS AND ASTRONOMY	GODDARD SPACE FLIGHT CENTER LOCATION 5101-AA, 940014	SPACE AND EARTH SCIENCES COMPUTING CTR-SPACE AND EARTH SCIENCES COMPUTING CENTER	ASTROPHYSICS MISSION OPERATIONS & DATA ANALYSIS	466.0
PHYSICS AND ASTRONOMY	GOODARD SPACE FLIGHT CENTER LOCATION 5101-AN, 940028	SPACE TELESCOPE SCIENCE SYSTEM-SPACE TELESCOPE SCIENCE SYSTEM	HUBBLE SPACE TELESCOPE (HST) OPERATIONS AND SERVICING	580.0
PHYSICS AND ASTRONOMY	GODDARD SPACE FLIGHT CENTER LOCATION 5103-AD, 940044	SPACECRAFT TECHNOLOGY SYSTEM-SPACECRAFT TECHNOLOGY SYSTEM	X-RAY TIMING EXPLORER (XTE) DEVELOPMENT	256.0
PHYSICS AND ASTRONOMY	GODDARD SPACE FLIGHT CENTER LOCATION 5103-AG, 940048	HIGH ENERGY ASTROPHYSICS DATA ACQ-HIGH ENERGY ASTROPHYSICS DATA ACQUISITION & PROC	X-RAY TIMING EXPLORER (XTE) DEVELOPMENT	313.0
PHYSICS AND ASTRONOMY	MARSHALL SPACE FLIGHT CENTER LOCATION 6203-PC, 940034	Payload Crew Training Complex-PAYLOAD CREW TRAINING COMPLEX	SPACELAB MISSION MGT--APPROVED MISSN	405.0

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SUMMARY OF MAJOR ADP EQUIPMENT AQUISITION OBLIGATIONS

PROGRAM BUDGET LINE ITEM	RECEIVING INSTALLATION BUILDING LOCATION, AND ADP/EAD CONTROL NUMBER	EQUIPMENT DESCRIPTION	PROGRAMMATIC PURPOSE	FY(94) OBLIGATIONS ($ IN THOUSANDS)
PLANETARY EXPLORATION	JET PROPULSION LABORATORY LOCATION 5516-SD, 910052	OPERATIONAL SYSTEMS-NOT SELECTED; CASSINI	MISSION OPERATIONS & DATA ANALYSIS	3037.0
PLANETARY EXPLORATION	JET PROPULSION LABORATORY LOCATION 5516-DP, 920044	DEVELOPMENT AND PROTOTYPE SYSTEMS-NOT SELECTED; SFOC REPLENISHMENT & SUSTAINING	MISSION OPERATIONS & DATA ANALYSIS	946 0
PLANETARY EXPLORATION	JET PROPULSION LABORATORY LOCATION 5516-SD, 920046	OPERATIONAL SYSTEMS-NOT SELECTED; MARS OBSERVWORKSTATIONS	MISSION OPERATIONS & DATA ANALYSIS	449 0
PLANETARY EXPLORATION	JET PROPULSION LABORATORY LOCATION 5516-SD, 920056	OPERATIONAL SYSTEMS-MIPS GLL ADAPTATION H/W ACQ AND MSTP	MISSION OPERATIONS & DATA ANALYSIS	2589.0
PLANETARY EXPLORATION	JET PROPULSION LABORATORY LOCATION 5516-DP, 920058	DEVELOPMENT AND PROTOTYPE SYSTEMS-NOT SELECTED; TEST STRING	MISSION OPERATIONS & DATA ANALYSIS	520 0
PLANETARY EXPLORATION	JET PROPULSION LABORATORY LOCATION 5516-DP, 93003B	DEVELOPMENT AND PROTOTYPE SYSTEMS-SYSTEM DEVELOPMENT	MISSION OPERATIONS & DATA ANALYSIS	1993 0
PLANETARY EXPLORATION	JET PROPULSION LABORATORY LOCATION 5500- , 940016	JPL - ADP ACTIVITY-COMPUTER PROCUREMENT	CASSINI	366 0
PLANETARY EXPLORATION	JET PROPULSION LABORATORY LOCATION 5500- , 940022	JPL - ADP ACTIVITY-RADSTONE BOARDS	CASSINI	277 0
PLANETARY EXPLORATION	JET PROPULSION LABORATORY LOCATION 5516-SD, 940036	OPERATIONAL SYSTEMS-SUPPORT EQUIPMENT	CASSINI	1164.0

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SUMMARY OF MAJOR ADP EQUIPMENT OBLIGATIONS

PROGRAM BUDGET LINE ITEM	RECEIVING INSTALLATION BUILDING LOCATION, AND ADP/EAO CONTROL NUMBER	EQUIPMENT DESCRIPTION	PROGRAMMATIC PURPOSE	FY(94) OBLIGATIONS ($ IN THOUSANDS)
SPACE APPLICATIONS	AMES RESEARCH CENTER LOCATION 21ED-03, 940028	NASA SCIENCE INTERNET OFFICE-HARDWARE PURCHASE	DATA SYSTEMS	1060 7
SPACE APPLICATIONS	GODDARD SPACE FLIGHT CENTER LOCATION 5101-AB, 940016	NATIONAL SPACE SCIENCE DATA CENTER SYS-NATIONAL SPACE SCIENCE DATA CENTER SYSTEM	DATA SYSTEMS	264 0
SPACE APPLICATIONS	GODDARD SPACE FLIGHT CENTER LOCATION 5103-AN, 940060	EARTH OBSERVING SYSTEM - DATA INFO SYS-EARTH OBSERVING SYSTEM - DATA INFORMATION SYSTEM	EARTH OBSERVING SYSTEM (EOS) DATA INFORMATION SYSTEM (DIS)	25010 0
SPACE APPLICATIONS	GODDARD SPACE FLIGHT CENTER LOCATION 5103-BE, 940064	APPLICATIONS IMAGE PROCESSING SYSTEM-APPLICATIONS IMAGE PROCESSING SYSTEM	TROPICAL RAINFALL MEASURING MISSION (TRMM)	845 0
SPACE APPLICATIONS	GODDARD SPACE FLIGHT CENTER LOCATION 5101-AA, 940256	SPACE AND EARTH SCIENCES COMPUTING CTR-SPACE AND EARTH SCIENCES COMPUTING CENTER	DATA SYSTEMS	7095 0
SPACE APPLICATIONS	GODDARD SPACE FLIGHT CENTER LOCATION 5101-AB, 940258	NATIONAL SPACE SCIENCE DATA CENTER SYS-NATIONAL SPACE SCIENCE DATA CENTER SYSTEM	DATA SYSTEMS	425 0
SPACE APPLICATIONS	JET PROPULSION LABORATORY LOCATION 5511-AA, 920014	ADMINISTRATIVE APPLICATIONS SYSTEMS-IBM 3090-200 ALTERNATE PURCHASE PLAN	APPL SYSTEMS ANALYSES AND STUDIES	1276 0
SPACE APPLICATIONS	JET PROPULSION LABORATORY LOCATION 5511-CN, 920016	COMMUNICATIONS AND NETWORK EQUIPMENT-INSTITUTIONAL LOCAL AREA NETWORK	APPL SYSTEMS ANALYSES AND STUDIES	550 0

SUMMARY OF MAJOR ADP EQUIPMNET AQUISTION OBLIGATIONS

PROGRAM BUDGET LINE ITEM	RECEIVING INSTALLATION BUILDING LOCATION, AND ADP/EAD CONTROL NUMBER	EQUIPMENT DESCRIPTION	PROGRAMMATIC PURPOSE	FY(84) OBLIGATIONS ($ IN THOUSANDS)
SPACE APPLICATIONS	JET PROPULSION LABORATORY LOCATION 5517-SS, 920072	ENGINEERING SERVICES SUPPORT SYSTEMS-CAD/CAE WORKSTATIONS AND PERIPHERAL EQUIPMENT	APPL SYSTEMS ANALYSES AND STUDIES	300.0
SPACE APPLICATIONS	JET PROPULSION LABORATORY LOCATION 5511-CN, 930014	COMMUNICATIONS AND NETWORK EQUIPMENT-BLDG. 525 COMMUNICATIONS	APPL SYSTEMS ANALYSES AND STUDIES	500.0
SPACE APPLICATIONS	JET PROPULSION LABORATORY LOCATION 5518-IL, 930042	INSTRUMENT LOAN POOL SUPPORT SYSTEMS-INSTRUMENT CONTROLLERS	APPL SYSTEMS ANALYSES AND STUDIES	1250.0
SPACE APPLICATIONS	JET PROPULSION LABORATORY LOCATION 5500- , 940026	JPL - ADP ACTIVITY-SUN WORKSTATIONS	APPL SYSTEMS ANALYSES AND STUDIES	300.0
SPACE APPLICATIONS	JET PROPULSION LABORATORY LOCATION 5517-TP, 940040	TECHNICAL DATA PROCESSING SUPPORT SYSTEM-GDPS & SDCS-SIRC/GRND OP SYS & SAR DATA CAT SYS	SHUTTLE/SPACELAB PAYLOAD DEVELOPMENT	582.0

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SUMMARY OF MAJOR ADP EQUIPMENT AQUISITION OBLIGATIONS

PROGRAM BUDGET LINE ITEM	RECEIVING INSTALLATION BUILDING LOCATION, AND ADP/EAD CONTROL NUMBER	EQUIPMENT DESCRIPTION	PROGRAMMATIC PURPOSE	FY(94) OBLIGATIONS ($ IN THOUSANDS)
COMMERCIAL USE OF SPACE	STENNIS SPACE CENTER LOCATION 6400- , 940016	Center ADP Activity-SCIENCE AND TECHNOLOGY LABORATORY COMMERCIAL	COMMERCIAL USE OF SPACE	425.0

SUMMARY OF MAJOR ADP EQUIPMENT AQUISITION OBLIGATIONS

PROGRAM BUDGET LINE ITEM	RECEIVING INSTALLATION BUILDING LOCATION, AND AOP/EAD CONTROL NUMBER	EQUIPMENT DESCRIPTION	PROGRAMMATIC PURPOSE	FY(94) OBLIGATIONS ($ IN THOUSANDS)
AERONAUTICAL RESEARCH & TECHNOLOGY	AMES RESEARCH CENTER LOCATION 21FL-01, 940040	AEROSPACE HUMAN FACTORS RESEARCH (DACI)-ACFS-COCKPIT GRAPHICS UPDATE	AERONAUTICS R&T BASE	320 1
AERONAUTICAL RESEARCH & TECHNOLOGY	AMES RESEARCH CENTER LOCATION 21FL-01, 940042	AEROSPACE HUMAN FACTORS RESEARCH (DACI)-ATC COMPUTER REHOSTING	AERONAUTICS R&T BASE	533 6
AERONAUTICAL RESEARCH & TECHNOLOGY	AMES RESEARCH CENTER LOCATION 21FS-00, 940044	FLIGHT SYSTEMS AND SIMULATION RESEARCH-HARDWARE PURCHASE	AERONAUTICS R&T BASE	1003 1
AERONAUTICAL RESEARCH & TECHNOLOGY	AMES RESEARCH CENTER LOCATION 21FS-01, 940046	FLIGHT SYSTEMS AND SIMULATION RESEARCH-HARDWARE PURCHASE	AERONAUTICS R&T BASE	426 8
AERONAUTICAL RESEARCH & TECHNOLOGY	AMES RESEARCH CENTER LOCATION 21RN-00, 940054	NUMERICAL AERODYNAMIC SIMULATION SYSTEMS-APPLIED RESEARCH - H/W	NUMERICAL AERODYNAMIC SIMULATION (NAS)	843.0
AERONAUTICAL RESEARCH & TECHNOLOGY	AMES RESEARCH CENTER LOCATION 21RN-00, 940056	NUMERICAL AERODYNAMIC SIMULATION SYSTEMS-DATA NETWORK SUBSYSTEMS	NUMERICAL AERODYNAMIC SIMULATION (NAS)	2652.0
AERONAUTICAL RESEARCH & TECHNOLOGY	AMES RESEARCH CENTER LOCATION 21RN-00, 940058	NUMERICAL AERODYNAMIC SIMULATION SYSTEMS-GRID DEVELOPMENT	NUMERICAL AERODYNAMIC SIMULATION (NAS)	384 0
AERONAUTICAL RESEARCH & TECHNOLOGY	AMES RESEARCH CENTER LOCATION 21RN-00, 940060	NUMERICAL AERODYNAMIC SIMULATION SYSTEMS-MASS STORAGE DEVELOPMENT	NUMERICAL AERODYNAMIC SIMULATION (NAS)	5336 0
AERONAUTICAL RESEARCH & TECHNOLOGY	AMES RESEARCH CENTER LOCATION 21RN-00, 940062	NUMERICAL AERODYNAMIC SIMULATION SYSTEMS-OPERATIONS H/W	NUMERICAL AERODYNAMIC SIMULATION (NAS)	1921 0

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SUMMARY OF MAJOR ADP EQUIPMENT AQUISTION OBLIGATIONS

PROGRAM BUDGET LINE ITEM	RECEIVING INSTALLATION BUILDING LOCATION, AND ADP/EAD CONTROL NUMBER	EQUIPMENT DESCRIPTION	PROGRAMMATIC PURPOSE	FY(94) OBLIGATIONS ($ IN THOUSANDS)
AERONAUTICAL RESEARCH & TECHNOLOGY	AMES RESEARCH CENTER LOCATION 21RN-00, 940066	NUMERICAL AERODYNAMIC SIMULATION SYSTEMS-SCIENT FIC ANALYSIS SYSTEMS	NUMERICAL AERODYNAMIC SIMULATION (NAS)	1067.0
AERONAUTICAL RESEARCH & TECHNOLOGY	AMES RESEARCH CENTER LOCATION 21RN-00, 940068	NUMERICAL AERODYNAMIC SIMULATION SYSTEMS-WKS DEVELOPMENT	NUMERICAL AERODYNAMIC SIMULATION (NAS)	3106 0
AERONAUTICAL RESEARCH & TECHNOLOGY	AMES RESEARCH CENTER LOCATION 21RT-00, 940072	THERMOSCIENCES DIVISION-HARDWARE PURCHASE (INSTR INITIATIVE)	AERONAUTICS R&T BASE	266 8
AERONAUTICAL RESEARCH & TECHNOLOGY	AMES RESEARCH CENTER LOCATION 21RO-01, 940074	AMES HPCCP CONSOLIDATED ADP-ADVANCED PROTOTYPE SYSTEMS-HARDWARE	HIGH-PERFORMANCE COMPUTING	800 3
AERONAUTICAL RESEARCH & TECHNOLOGY	AMES RESEARCH CENTER LOCATION 21RO-01, 940078	AMES HPCCP CONSOLIDATED ADP-HARDWARE PUCHASES-ROUTERS;DSU/CSU (EDC)	HIGH-PERFORMANCE COMPUTING	885 7
AERONAUTICAL RESEARCH & TECHNOLOGY	AMES RESEARCH CENTER LOCATION 21RO-01, 940080	AMES HPCCP CONSOLIDATED ADP-HIGH PERFORMANCE COMPUTING RESEARCH-H/W	HIGH-PERFORMANCE COMPUTING	6829 4
AERONAUTICAL RESEARCH & TECHNOLOGY	AMES RESEARCH CENTER LOCATION 21FS-01, 940120	FLIGHT SYSTEMS AND SIMULATION RESEARCH-HARDWARE LEASE	AERONAUTICS R&T BASE	373 5
AERONAUTICAL RESEARCH & TECHNOLOGY	AMES RESEARCH CENTER LOCATION 21RN-00, 940126	NUMERICAL AERODYNAMIC SIMULATION SYSTEMS-HIGH SPEED PROCESSOR 3	NUMERICAL AERODYNAMIC SIMULATION (NAS)	3537.0
AERONAUTICAL RESEARCH & TECHNOLOGY	AMES RESEARCH CENTER LOCATION 21RN-00, 940128	NUMERICAL AERODYNAMIC SIMULATION SYSTEMS-HIGH SPEED PROCESSOR 4	NUMERICAL AERODYNAMIC SIMULATION (NAS)	5232.0

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SUMMARY OF MAJOR ADP EQUIPMENT AQUISITION OBLIGATIONS

PROGRAM BUDGET LINE ITEM	RECEIVING INSTALLATION BUILDING LOCATION, AND ADP/EAD CONTROL NUMBER	EQUIPMENT DESCRIPTION	PROGRAMMATIC PURPOSE	FY(94) OBLIGATIONS ($ IN THOUSANDS)
AERONAUTICAL RESEARCH & TECHNOLOGY	AMES RESEARCH CENTER LOCATION 21RN-00, 940138	NUMERICAL AERODYNAMIC SIMULATION SYSTEMS-OPERATIONS-HSP4	NUMERICAL AERODYNAMIC SIMULATION (NAS)	2215 0
AERONAUTICAL RESEARCH & TECHNOLOGY	AMES RESEARCH CENTER LOCATION 21RN-00, 940140	NUMERICAL AERODYNAMIC SIMULATION SYSTEMS-PROGRAM SUPPORT	NUMERICAL AERODYNAMIC SIMULATION (NAS)	651.0
AERONAUTICAL RESEARCH & TECHNOLOGY	LEWIS RESEARCH CENTER LOCATION 2201-VC, 890030	CENTRAL SCIENTIFIC CLUSTER-CENTRAL SCIEN CLUSTER HARDWARE	AERONAUTICS R&T BASE	325 0
AERONAUTICAL RESEARCH & TECHNOLOGY	LEWIS RESEARCH CENTER LOCATION 2201-03, 900036	CADAM SYS-SCIENTIFIC SYSTEM HARDWARE	AERONAUTICS R&T BASE	500.0
AERONAUTICAL RESEARCH & TECHNOLOGY	LEWIS RESEARCH CENTER LOCATION 2200- , 930018	LERC - ADP ACTIVITY-LEWIS INFO. NETWK COMPONENTS	AERONAUTICS R&T BASE	520 0
AERONAUTICAL RESEARCH & TECHNOLOGY	LEWIS RESEARCH CENTER LOCATION 2200- , 930020	LERC - ADP ACTIVITY-MAINT/ OPERATIONS CONTRACT (CCNS)	AERONAUTICS R&T BASE	1058.0
AERONAUTICAL RESEARCH & TECHNOLOGY	LEWIS RESEARCH CENTER LOCATION 2201-07, 930026	SCIENTIFIC MINI SUPER SYS-CONVEX COMPUTER HARDWARE	AERONAUTICS R&T BASE	300 0
AERONAUTICAL RESEARCH & TECHNOLOGY	LEWIS RESEARCH CENTER LOCATION 2201-08, 930028	LEWIS INFO MANAGEMENT SYS-LEWIS INFO MGT SYS HARDWARE	AERONAUTICS R&T BASE	344 0
AERONAUTICAL RESEARCH & TECHNOLOGY	LEWIS RESEARCH CENTER LOCATION 2202-93, 930036	TRADAR REPLACEMENT-TRANSIENT DATA RECORDER III H/W	AERONAUTICS R&T BASE	250 0

SUMMARY OF MAJOR ADP EQUIPMENT AQUISITION OBLIGATIONS

PROGRAM BUDGET LINE ITEM	RECEIVING INSTALLATION BUILDING LOCATION, AND ADP/EAO CONTROL NUMBER	EQUIPMENT DESCRIPTION	PROGRAMMATIC PURPOSE	FY(94) OBLIGATIONS ($ IN THOUSANDS)
AERONAUTICAL RESEARCH & TECHNOLOGY	LEWIS RESEARCH CENTER LOCATION 2200- . 940014	LERC - ADP ACTIVITY-ARCHIVAL MASS STORAGE HARDWARE	AERONAUTICS R&T BASE	520 0
AERONAUTICAL RESEARCH & TECHNOLOGY	LEWIS RESEARCH CENTER LOCATION 2201-03, 940020	CADAM SYS-INTERACTIVE COMP ASSISTED RES & ENGR SYS HDW	AERONAUTICS R&T BASE	250 0
AERONAUTICAL RESEARCH & TECHNOLOGY	LEWIS RESEARCH CENTER LOCATION 2201-04, 940030	HIGH SPEED COMPUTATIONAL SYS-SUPER-COMPUTER HARDWARE	AERONAUTICS R&T BASE	11300 0
AERONAUTICAL RESEARCH & TECHNOLOGY	LANGLEY RESEARCH CENTER LOCATION 2302-10, 890018	LARC CENTRAL SCIENTIFIC COMPUTER COMPLEX-MASS STORAGE	AERONAUTICS R&T BASE	1000 0
AERONAUTICAL RESEARCH & TECHNOLOGY	LANGLEY RESEARCH CENTER LOCATION 2302-10, 890026	LARC CENTRAL SCIENTIFIC COMPUTER COMPLEX-NETWORKS LOCAL AND DISTRIBUTED	AERONAUTICS R&T BASE	1000 0
AERONAUTICAL RESEARCH & TECHNOLOGY	LANGLEY RESEARCH CENTER LOCATION 2302-10, 890028	LARC CENTRAL SCIENTIFIC COMPUTER COMPLEX-SUPER COMPUTING AND MASSIVELY PARALLEL	AERONAUTICS R&T BASE	9100 0
AERONAUTICAL RESEARCH & TECHNOLOGY	LANGLEY RESEARCH CENTER LOCATION 2302-10, 890034	LARC CENTRAL SCIENTIFIC COMPUTER COMPLEX-PERIPHERALS-SIMULATION GRAPHICS	AERONAUTICS R&T BASE	3900 0
AERONAUTICAL RESEARCH & TECHNOLOGY	LANGLEY RESEARCH CENTER LOCATION 2304-20, 910042	STRUCTURES RESEARCH DATA SYSTEMS-TDT DATA SYS UPGRADE	AERONAUTICS R&T BASE	700.0

SUMMARY OF MAJOR ADP EQUIPMENT AQUISITION OBLIGATIONS

PROGRAM BUDGET LINE ITEM	RECEIVING INSTALLATION BUILDING LOCATION, AND ADP/EAO CONTROL NUMBER	EQUIPMENT DESCRIPTION	PROGRAMMATIC PURPOSE	FY(94) OBLIGATIONS ($ IN THOUSANDS)
AERONAUTICAL RESEARCH & TECHNOLOGY	LANGLEY RESEARCH CENTER LOCATION 2304-30, 930036	AERONAUTICS RESEARCH DATA SYSTEMS-UNITARY PLAN WIND TUNNEL UPGRADE	AERONAUTICS R&T BASE	400 0
AERONAUTICAL RESEARCH & TECHNOLOGY	LANGLEY RESEARCH CENTER LOCATION 2304-20, 930044	STRUCTURES RESEARCH DATA SYSTEMS-STRUCTURES COMPLEX UPGRADE	AERONAUTICS R&T BASE	250 0
AERONAUTICAL RESEARCH & TECHNOLOGY	LANGLEY RESEARCH CENTER LOCATION 2302-10, 940012	LARC CENTRAL SCIENTIFIC COMPUTER COMPLEX-HIGH PERFORMANCE COMPUTING	HIGH-PERFORMANCE COMPUTING	900.0

SUMMARY OF MAJOR ADP EQUIPMENT AQUISITION OBLIGATIONS

PROGRAM BUDGET LINE ITEM	RECEIVING INSTALLATION BUILDING LOCATION, AND ADP/EAD CONTROL NUMBER	EQUIPMENT DESCRIPTION	PROGRAMMATIC PURPOSE	FY(94) OBLIGATIONS ($ IN THOUSANDS)
SPACE SHUTTLE PRODUCTION AND OPERATIONAL CAPABILITY	KENNEDY SPACE CENTER LOCATION 7601-F1, 940012	Central Data System-CENTRAL DATA SYSTEM	LAUNCH SITE EQUIPMENT	920.0
SPACE SHUTTLE PRODUCTION AND OPERATIONAL CAPABILITY	KENNEDY SPACE CENTER LOCATION 7601-M1, 940016	Checkout, Control and Monitor System-CHECKOUT, CONTROL, & MONITOR SUBSYSTEM	LAUNCH SITE EQUIPMENT	8843.0

SUMMARY OF MAJOR EQUIPMENT AQUISITION OBLIGATIONS

PROGRAM BUDGET LINE ITEM	RECEIVING INSTALLATION BUILDING LOCATION, AND ADP/EAO CONTROL NUMBER	EQUIPMENT DESCRIPTION	PROGRAMMATIC PURPOSE	FY(94) OBLIGATIONS ($ IN THOUSANDS)
SPACE TRANSPORTATION OPERATIONS	MARSHALL SPACE FLIGHT CENTER LOCATION 6202-01, 940018	Slidell Computer Complex-FR-80 REPLACEMENT	FLIGHT HAROWARE	386.0
SPACE TRANSPORTATION OPERATIONS	MARSHALL SPACE FLIGHT CENTER LOCATION 6203-MI, 940030	Meteorological Interactive Data Disp Sys-METEOROLOGICAL INTERACTIVE DATA DISPLAY SYSTEM	FLIGHT HAROWARE	400 0
SPACE TRANSPORTATION OPERATIONS	MARSHALL SPACE FLIGHT CENTER LOCATION 6202-01, 940092	Slidell Computer Complex-SLIDELL COMPUTER COMPLEX MASS STORAGE AUGMENTATION	FLIGHT HAROWARE	505.0
SPACE TRANSPORTATION OPERATIONS	MARSHALL SPACE FLIGHT CENTER LOCATION 6202-01, 940094	Slidell Computer Complex-TAPE CARTRIDGE SUBSYSTEM AUTOMATION	FLIGHT HAROWARE	460.0
SPACE TRANSPORTATION OPERATIONS	JOHNSON SPACE CENTER LOCATION 72CA-C3, 940014	Flight Crew Operations Office	FLIGHT OPERATIONS	528.0
SPACE TRANSPORTATION OPERATIONS	JOHNSON SPACE CENTER LOCATION 72CA-C4, 940018	Shuttle Training Software-SHUTTLE TRNG AIRCRAFT SYSTEMS SUPP	FLIGHT OPERATIONS	261.0
SPACE TRANSPORTATION OPERATIONS	JOHNSON SPACE CENTER LOCATION 72DA-DA, 940020	Flight Design Computation Facility-FLIGHT DESIGN COMP FAC RECURRING MAINT	FLIGHT OPERATIONS	263 0
SPACE TRANSPORTATION OPERATIONS	JOHNSON SPACE CENTER LOCATION 72DA-DB, 940022	Software Production Facility-S/W PRODUCTION FAC RECURRING MAINT	FLIGHT OPERATIONS	366 0

890

SUMMARY OF MAJOR ADP EQUIPMENT AQUISITION OBLIGATIONS

PROGRAM BUDGET LINE ITEM	RECEIVING INSTALLATION BUILDING LOCATION, AND AOP/EAO CONTROL NUMBER	EQUIPMENT DESCRIPTION	PROGRAMMATIC PURPOSE	FY(94) OBLIGATIONS ($ IN THOUSANDS)
SPACE TRANSPORTATION OPERATIONS	JOHNSON SPACE CENTER LOCATION 720A-OC, 940024	MOO Consolidated Support-CONSOLIDATED SUPP IMPROVEMENT	FLIGHT OPERATIONS	3977 0
SPACE TRANSPORTATION OPERATIONS	JOHNSON SPACE CENTER LOCATION 720A-OC, 940026	MOO Consolidated Support-CONSOLIDATED SUPPORT RECURRING MAINT	FLIGHT OPERATIONS	4566 0
SPACE TRANSPORTATION OPERATIONS	JOHNSON SPACE CENTER LOCATION 720A-01, 940028	MOO Office Automation-MISSION OPS OIR EQUIPMENT REPLACEMENT	FLIGHT OPERATIONS	6871 0
SPACE TRANSPORTATION OPERATIONS	JOHNSON SPACE CENTER LOCATION 720A-02, 940034	Mission Control Center-MISSION CONTROL CENTER RECURRING MAINT	FLIGHT OPERATIONS	554 0
SPACE TRANSPORTATION OPERATIONS	JOHNSON SPACE CENTER LOCATION 720A-08, 940088	Shuttle Avionics & Integration Lab-SHUTTLE AVIONIC INTEGRATION LAB RECURRING MAINT	FLIGHT OPERATIONS	289.0
SPACE TRANSPORTATION OPERATIONS	JOHNSON SPACE CENTER LOCATION 72EA-EC, 940092	Crew and Thermal Engineering Systems-CREW AND THERMAL ENGINEERING PURCHASE AOP HARDWA	FLIGHT OPERATIONS	933 1
SPACE TRANSPORTATION OPERATIONS	JOHNSON SPACE CENTER LOCATION 72EA-EG, 940102	Navigation, Control and	FLIGHT OPERATIONS	799 0
SPACE TRANSPORTATION OPERATIONS	JOHNSON SPACE CENTER LOCATION 72EA-EK, 940104	Flight Data Systems-FLIGHT DATA SYSTEMS PURCHASE AOP HARDWA	FLIGHT OPERATIONS	824 0

SUMMARY OF MAJOR ADP EQUIPMENT AQUISITION OBLIGATIONS

PROGRAM BUDGET LINE ITEM	RECEIVING INSTALLATION BUILDING LOCATION, AND AOP/EAO CONTROL NUMBER	EQUIPMENT DESCRIPTION	PROGRAMMATIC PURPOSE	FY(94) OBLIGATIONS ($ IN THOUSANDS)
SPACE TRANSPORTATION OPERATIONS	JOHNSON SPACE CENTER LOCATION 72EA-EP, 940106	Propulsion and Power	FLIGHT OPERATIONS	275 1
SPACE TRANSPORTATION OPERATIONS	JOHNSON SPACE CENTER LOCATION 72EA-ES, 940114	Structures & Mechanics Engineering Sys-STRUCTURES & MECHANICS ENGINEE PURCHASE AOP HARDWA	FLIGHT OPERATIONS	749 0
SPACE TRANSPORTATION OPERATIONS	JOHNSON SPACE CENTER LOCATION 72EA-ET, 940120	Systems Engineering Division-SYSTEMS ENGINEERING DIVISION PURCHASE AOP HARDWA	FLIGHT OPERATIONS	539 0
SPACE TRANSPORTATION OPERATIONS	JOHNSON SPACE CENTER LOCATION 72EA-P5, 940124	ISD Center Information System-INFO SYS DIR INSTITUTIONAL SUPPORT FOR ENG DIR	FLIGHT OPERATIONS	300 0
SPACE TRANSPORTATION OPERATIONS	JOHNSON SPACE CENTER LOCATION 72EA-P9, 940126	ISD JSC Engineering & Science Network-INFO SYS DIR INSTITUTIONAL SUPPORT FOR ENG DIR	FLIGHT OPERATIONS	376 0
SPACE TRANSPORTATION OPERATIONS	JOHNSON SPACE CENTER LOCATION 72GA-G1, 940128	Integrated Management	FLIGHT OPERATIONS	870.0
SPACE TRANSPORTATION OPERATIONS	JOHNSON SPACE CENTER LOCATION 72PA-PD, 940192	Customer Support-USER WORK STATION RESUPPLY, SPARES CSC	FLIGHT OPERATIONS	322 0
SPACE TRANSPORTATION OPERATIONS	JOHNSON SPACE CENTER LOCATION 72PA-P5, 940206	Center Information System-CENTER INFO SYS HOST UPGRADE	FLIGHT OPERATIONS	1735.1

SUMMARY OF MAJOR ADP EQUIPMENT AQUISITION OBLIGATIONS

PROGRAM BUDGET LINE ITEM	RECEIVING INSTALLATION BUILDING LOCATION, AND ADP/EAD CONTROL NUMBER	EQUIPMENT DESCRIPTION	PROGRAMMATIC PURPOSE	FY(94) OBLIGATIONS ($ IN THOUSANDS)
SPACE TRANSPORTATION OPERATIONS	JOHNSON SPACE CENTER LOCATION 72PA-P6, 940208	Software Technology Lab-SOFTWARE TECHNOLOGY LAB PURCHASE ADP HARDWA	FLIGHT OPERATIONS	365 1
SPACE TRANSPORTATION OPERATIONS	JOHNSON SPACE CENTER LOCATION 72PA-P8, 940214	JSC Information Network and FMNET-JSC INFO NTWK NEW MATERIALS	FLIGHT OPERATIONS	640 0
SPACE TRANSPORTATION OPERATIONS	JOHNSON SPACE CENTER LOCATION 72SA-S5, 940234	Crew Compartment Configuration-SP/MAN-SYSTEMS DIV FIPR HARDWARE	FLIGHT OPERATIONS	689 0
SPACE TRANSPORTATION OPERATIONS	JOHNSON SPACE CENTER LOCATION 72PA-P5, 940422	Center Information System-CENTER INFO SYS HOST UPGRADE	FLIGHT OPERATIONS	545 1
SPACE TRANSPORTATION OPERATIONS	KENNEDY SPACE CENTER LOCATION 7623-S5, 940128	LPS Software Development Network-LPS S/W DEVELOP NETWORK	LAUNCH AND LANDING OPERATIONS	830 0
SPACE TRANSPORTATION OPERATIONS	KENNEDY SPACE CENTER LOCATION 7623-25, 940132	SPC Design Engineering Computer System-SPC DESIGN ENGR COMPUTER SYS	LAUNCH AND LANDING OPERATIONS	320 0
SPACE TRANSPORTATION OPERATIONS	KENNEDY SPACE CENTER LOCATION 7629-A4, 940148	Microcomputing Support-MICRO COMPUTING SUPPORT	FLIGHT OPERATIONS	256 0
SPACE TRANSPORTATION OPERATIONS	KENNEDY SPACE CENTER LOCATION 7602-J3, 940296	Kennedy Inventory Management System-KENNEDY INVENTORY MANAGEMENT SYSTEM	FLIGHT OPERATIONS	526 0

SUMMARY OF MAJOR ADP EQUIPMENT AQUISITION OBLIGATIONS

PROGRAM BUDGET LINE ITEM	RECEIVING INSTALLATION BUILDING LOCATION, AND ADP/EAO CONTROL NUMBER	EQUIPMENT DESCRIPTION	PROGRAMMATIC PURPOSE	FY(94) OBLIGATIONS ($ IN THOUSANDS)
EXPENDABLE LAUNCH VEHICLES	KENNEDY SPACE CENTER LOCATION 7605-83, 940046	Expendable Vehicles Telemetry System-EXPENDABLE VEHICLES TELEMETRY SYSTEMS	DELTA	700 0

SUMMARY OF MAJOR ADP EQUIPMENT AQUISITION OBLIGATIONS

PROGRAM BUDGET LINE ITEM	RECEIVING INSTALLATION BUILDING LOCATION, AND ADP/EAD CONTROL NUMBER	EQUIPMENT DESCRIPTION	PROGRAMMATIC PURPOSE	FY(94) OBLIGATIONS ($ IN THOUSANDS)
SPACE AND GROUND NETWORK, COMMUNICATIONS AND DATA SYSTEMS	AMES RESEARCH CENTER LOCATION 21XR-01, 940090	DRYDEN RESEARCH ENGINEERING DIVISION - C-SERV I - HARDWARE PURCHASE	GROUND NETWORK	443 9
SPACE AND GROUND NETWORK, COMMUNICATIONS AND DATA SYSTEMS	AMES RESEARCH CENTER LOCATION 21XR-01, 940092	DRYDEN RESEARCH ENGINEERING DIVISION - C-TRACKING SYS UPGRADES	GROUND NETWORK	277 4
SPACE AND GROUND NETWORK, COMMUNICATIONS AND DATA SYSTEMS	AMES RESEARCH CENTER LOCATION 21XR-01, 940094	DRYDEN RESEARCH ENGINEERING DIVISION - C-TRAPS SYS UPGRADE	GROUND NETWORK	2325 2
SPACE AND GROUND NETWORK, COMMUNICATIONS AND DATA SYSTEMS	GODDARD SPACE FLIGHT CENTER LOCATION 5101-AC, 940018	CENTRAL TELEMETRY DP AND DATA HANDLING-CENTRAL TELEMETRY DATA PROCESSING & DATA SYSTEM	COMMUNICATIONS AND DATA SYSTEMS	2100 0
SPACE AND GROUND NETWORK, COMMUNICATIONS AND DATA SYSTEMS	GODDARD SPACE FLIGHT CENTER LOCATION 5103-BG, 940066	SPACELAB INPUT PROCESSING SYSTEM-SPACELAB INPUT PROCESSING SYSTEM	COMMUNICATIONS AND DATA SYSTEMS	1630 0
SPACE AND GROUND NETWORK, COMMUNICATIONS AND DATA SYSTEMS	GODDARD SPACE FLIGHT CENTER LOCATION 5103-BK, 940068	MISSION AND DATA OPERATIONS TEST BED PRO-MISSION & DATA OPERATIONS TEST BED PROCESSING	COMMUNICATIONS AND DATA SYSTEMS	1414 0
SPACE AND GROUND NETWORK, COMMUNICATIONS AND DATA SYSTEMS	GODDARD SPACE FLIGHT CENTER LOCATION 5104-AA, 940090	NASA COMMUNICATIONS SYSTEM (NASCOM)-NASA COMMUNICATIONS SYSTEM (NASCOM)	COMMUNICATIONS AND DATA SYSTEMS	906 0

SUMMARY OF MAJOR ADP EQUIPMENT AQUISITION OBLIGATIONS

PROGRAM BUDGET LINE ITEM	RECEIVING INSTALLATION BUILDING LOCATION, AND AOP/EAO CONTROL NUMBER	EQUIPMENT DESCRIPTION	PROGRAMMATIC PURPOSE	FY(94) OBLIGATIONS ($ IN THOUSANDS)
SPACE AND GROUND NETWORK, COMMUNICATIONS AND DATA SYSTEMS	GODDARD SPACE FLIGHT CENTER LOCATION 5106-AE, 940098	MULTI-SATELLITE OPERATIONS CONTROL CTR-MULTI-SATELLITE OPERATIONS CONTROL CENTER	COMMUNICATIONS AND DATA SYSTEMS	10157 0
SPACE AND GROUND NETWORK, COMMUNICATIONS AND DATA SYSTEMS	GODDARD SPACE FLIGHT CENTER LOCATION 5106-BB, 940102	COMMAND MANAGEMENT SYSTEM-COMMAND MANAGEMENT SYSTEM	COMMUNICATIONS AND DATA SYSTEMS	1447 0
SPACE AND GROUND NETWORK, COMMUNICATIONS AND DATA SYSTEMS	GODDARD SPACE FLIGHT CENTER LOCATION 5106-BC, 940104	OPERATIONS SUPPORT COMPUTING FAC SYS-OPERATIONS SUPPORT COMPUTING FACILITY SYSTEM	COMMUNICATIONS AND DATA SYSTEMS	2970.0
SPACE AND GROUND NETWORK, COMMUNICATIONS AND DATA SYSTEMS	GODDARD SPACE FLIGHT CENTER LOCATION 5106-BD, 940106	SHUTTLE POCC INTERFACE FACILITY SYSTEM-SHUTTLE POCC INTERFACE FACILITY SYSTEM	COMMUNICATIONS AND DATA SYSTEMS	3995 0
SPACE AND GROUND NETWORK, COMMUNICATIONS AND DATA SYSTEMS	GODDARD SPACE FLIGHT CENTER LOCATION 5101-AC, 940260	CENTRAL TELEMETRY OP AND DATA HANDLING-CENTRAL TELEMETRY DATA PROCESSING & DATA SYSTEM	COMMUNICATIONS AND DATA SYSTEMS	301 0
SPACE AND GROUND NETWORK, COMMUNICATIONS AND DATA SYSTEMS	GODDARD SPACE FLIGHT CENTER LOCATION 5105-AB, 940268	TRACKING AND DATA RELAY SATELLITE SYSTEM-TRACKING AND DATA RELAY SATELLITE SYSTEM	SPACE NETWORK	300 0
SPACE AND GROUND NETWORK, COMMUNICATIONS AND DATA SYSTEMS	JET PROPULSION LABORATORY LOCATION 5512-DD, 900034	DEEP SPACE NETWORK OPERATIONAL SYSTEMS-HIGH RATE TELEMETRY	GROUND NETWORK	400 0

SUMMARY OF MAJOR ADP EQUIPMNET AQUISITION OBLIGATIONS

PROGRAM BUDGET LINE ITEM	RECEIVING INSTALLATION BUILDING LOCATION, AND ADP/EAD CONTROL NUMBER	EQUIPMENT DESCRIPTION	PROGRAMMATIC PURPOSE	FY(94) OBLIGATIONS ($ IN THOUSANDS)
SPACE AND GROUND NETWORK, COMMUNICATIONS AND DATA SYSTEMS	JET PROPULSION LABORATORY LOCATION 5512-GO, 930016	GROUND COMMUNICATION OPERATIONAL SYSTEMS-MODCOMP 97XX PROCESSORS & PERIPHERAL EQUIPMENT	COMMUNICATIONS AND DATA SYSTEMS	800 0
SPACE AND GROUND NETWORK, COMMUNICATIONS AND DATA SYSTEMS	JET PROPULSION LABORATORY LOCATION 5512-NO, 930024	NETWORK OPERATIONS CONTROL CENTER-OSP SPLIT STRING HARDWARE	GROUND NETWORK	483.0
SPACE AND GROUND NETWORK, COMMUNICATIONS AND DATA SYSTEMS	JET PROPULSION LABORATORY LOCATION 5500- , 940020	JPL - AOP ACTIVITY-LAN HARDWARE FOR SPC UPGRADE	GROUND NETWORK	375 0
SPACE AND GROUND NETWORK, COMMUNICATIONS AND DATA SYSTEMS	JET PROPULSION LABORATORY LOCATION 5512-CN, 940028	COMMUNICATIONS AND NETWORK EQUIPMENT-DIGITAL VOICE EQUIPMENT	COMMUNICATIONS AND DATA SYSTEMS	1600 0
SPACE AND GROUND NETWORK, COMMUNICATIONS AND DATA SYSTEMS	JET PROPULSION LABORATORY LOCATION 5512-GO, 940030	GROUND COMMUNICATION OPERATIONAL SYSTEMS-GCF UPGRADE	COMMUNICATIONS AND DATA SYSTEMS	300 0
SPACE AND GROUND NETWORK, COMMUNICATIONS AND DATA SYSTEMS	MARSHALL SPACE FLIGHT CENTER LOCATION 6218-01, 940070	Program Support Communication Network-PROGRAM SUPPORT COMM NETWORK EQUIPMENT	COMMUNICATIONS AND DATA SYSTEMS	7089 0

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